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THESIS

ANNUAL SCHEDULING OF ATLANTIC FLEET
NAVAL COMBATANTS

by

Clarke E. Goodman Jr.

March 1985

Thesis Advisor: R. Kevin Wood

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This study provides a mathematical programming model to assist employ-

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The model is tested using data from the 1983 Atlantic Fleet schedule for carriers and surface combatants. The data involving 111 ships, 19 major events, 73 separate ship-type requirements, and 44 force weapon system capability requirements yields a set covering problem with 10,723 variables and 228 constraints. This problem is solved on an IBM 3033 AP in 84 seconds of CPU time.

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Annual Scheduling of Atlantic Fleet Naval Combatants

by

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Lieutenant, United States Navy
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Submitted in partial fulfillment of the
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I. INTRODUCTION

> In its broadest sense, fleet readiness is the degree to which the force is ready to carry out its mission to wage prompt and sustained combat at sea. Supporting military strategy involves not only having units properly manned, trained, equipped, and supported, but also deployed to positions from which they may be able to best support U.S. interests and rapidly engage potential enemies....A properly balanced employment schedule is essential to attain high states of readiness, because the individual requirements for maintenance, training, and morale are frequently in competition with each other. [Ref. 1]

Employment scheduling is the process whereby U. S. Navy ships, submarines, aircraft and other units are assigned to major operations, exercises, maintenance periods, inspections and other events. The effectiveness of the employment scheduling process directly influences overall fleet combat readiness. Currently, this process is largely manual requiring several full time scheduling officers and additional personnel at various levels of management. This study develops and implements an optimization model that automates a substantial part of the employment scheduling problem. The model is formulated as a generalized set covering problem and may be applied to a number of independent subsets of the employment scheduling problem. For explanatory purposes, the model is applied to the annual planning schedule for naval combatants of the Atlantic Fleet.

A. CURRENT PROCEDURES

The Atlantic Fleet Employment Schedule details the day-to-day operations of the 700 to 750 units that comprise the Atlantic Fleet. The schedule is one of the primary methods for managing these fleet assets. Requests for fleet units to

participate in events, referred to as *event requests* in this study, originate from several sources, e.g., Secretary of Defense, Chief of Naval Operations, Type Commanders, Fleet Commanders, Group Commanders, Squadron Commanders, and individual unit commanders. Fleet assets are always in short supply relative to the demands resulting from all event requests. Fleet schedulers are faced with the problem of selecting which event requests will be scheduled and how to most efficiently schedule those events. The size and complexity of this scheduling problem demands the resources of numerous management personnel, e.g., operation and planning staffs, at all levels in the command structure.

Current Navy employment schedules are produced with little computer assistance. The Commander in Chief Atlantic Fleet (CINCLANTFLT) convenes a scheduling conference each quarter. This conference is the culmination of the employment scheduling process and results in publication of a detailed quarterly employment schedule with annual schedule projections. CINCLANTFLT's conference is preceded by Type Commander scheduling conferences. The Type Commander conferences are the working conferences where schedules are developed. At these conferences, rough schedules are proposed, reviewed, discussed, conflicts resolved, and bargains made until a final schedule is selected for submission to CINCLANTFLT. In the overall process, computers are only used to store and retrieve schedule data; they are not used to assist decision-making.

CINCLANTFLT is the overall schedule coordinator. Fleet assets are managed by the Type Commanders who, in turn, delegate part of their management responsibilities to group, squadron and unit commanders. CINCLANTFLT and the operational fleet commander (OPFLT) are primarily

concerned with meeting major operational commitments while Type Commanders and lower levels of command are principally concerned with maintenance, inspections, and training.

B. PROBLEM SCOPE

The entire employment scheduling problem is formidable. However, because of its structure, the problem can be divided into independent subproblems of manageable size. This study develops a model for the *Combatant Primary Event Schedule* (CPSKED) problem. The derivation of this problem from the overall employment scheduling problem is discussed in this section; the resulting CPSKED problem is defined in detail in Chapter II.

CINCLANTFLT has operational commitments in the home fleet (Second Fleet) and abroad. These commitments result from event requests that have been approved for inclusion in the fleet schedule and are referred to in this study as *primary events*. Primary events include all extended operations and major exercises. These events are the most important and the most demanding events in the fleet schedule. Other events are classified as either *major maintenance events* or *secondary events* and may be viewed as events necessary to support the successful conduct of primary events.

This study focuses on scheduling ships to the CINCLANTFLT primary events. It is assumed that (1) all primary events are fixed in start time and duration, and (2) all primary events are uniformly more important than supporting events. Assumption 1 effectively separates the process of the timing of primary events from the problem of scheduling (assigning) ships to these events. This is a good approximation of current Naval practice since most

commitments are made years in advance without detailed knowledge of future fleet assets, and also because of long-term fixed commitments. Assumption 2 allows assignment of ships to primary events without requiring concomitant scheduling of secondary events, although time must be set aside in a ship's primary event schedule to allow for subsequent scheduling of secondary events. Thus, with the above assumptions the problems of determining which events to schedule and when to schedule them are presumed solved. The remaining problem is to determine which fleet assets should be used to satisfy the primary event requirements while distributing the workload equitably among the ships.

Fleet assets may be divided into the following functional categories: naval combatant units, amphibious units, marine units, support units, submarine units, and aviation units. Within a functional category, unit operational capabilities are similar and units are employed in similar missions. Hence, substitutions within a functional category may be allowed but substitutions across category bounds are not allowed. Primary events may require assets from one or more of these functional categories; however, since substitutions are confined to functional categories, an individual asset requirement for a primary event is dependent on only one functional category. Consequently, the CPSKED model can be developed to generate annual planning schedules for assigning assets from one functional category, naval combatants in this study, to primary events without regard to other functional categories. Primary event scheduling problems considering other functional categories, e.g., amphibious units, aviation units, submarines, or support ships, can be formulated in a manner analogous to the methods presented in this study.

An instance of the CPSKED problem consists of 19 primary events and 111 ships based on 1983 historical data. The primary events may require assets by ship-type and/or weapon system capability. The 19 primary events translate to 73 event/ship-type requirements and 44 force weapon system capability constraints. The goal is to select the best annual planning schedule from all possible candidate schedules.

C. THE NEED FOR COMPUTER ASSISTANCE

Scheduling decisions directly affect fleet readiness and fleet operational performance.

> The optimized peacetime employment schedule which has as its objective maximizing combat readiness should always be the goal and guide. [Ref. 1]

Unfortunately, readiness is a vague measure which cannot be directly optimized. However, computers can be used effectively as management tools to assure that the employment schedule provides the best opportunity to maintain readiness at the highest level possible.

The opportunity to maintain readiness can be measured in terms of efficient utilization of fleet assets. The unnecessary over-employment of fleet assets adversely affects personnel morale and reduces the opportunities for maintenance and training. While over-employment is considered more detrimental to fleet readiness, under-employment results in deficiencies in operational experience with a consequent reduction in overall readiness. Thus, the effect of either over-employment or under-employment of fleet assets is a reduction in fleet readiness. In addition, assignment of a suboptimal mix of forces and capabilities to perform an operational mission or major exercise will result in degraded performance and,

in the extreme, may result in failure to achieve the objectives of the mission or exercise.

Navy employment schedules have been successfully produced for years without the assistance of computers or computer models. Furthermore, because of the unpredictable nature of ships and navy operations, it is unlikely that computer models will ever be sufficiently sophisticated to replace fleet schedulers. Computer models can, however, become valuable tools to assist fleet schedulers. Computer models may be used to speed up the process of generating a schedule and conduct "what-if" analysis on a schedule proposal. Additionally, an optimization model can provide a method of measuring the relative merit of different schedule proposals.

Currently, there exist no concrete methods for judging the acceptability of a proposed schedule. Experienced schedulers have an intuitive feeling, based on Navy policy and guidelines, about the merit of a proposed schedule. The mathematical modeling process requires that the scheduler's intuition be replaced by concrete rules and measurable criteria, yielding an analytic framework for comparing proposed schedules. Thus, the modeling process provides additional insight into the scheduling problem and results in a standardized method for evaluating a proposed schedule. The ability to critically evaluate and compare alternative proposals is potentially the greatest management tool to be gained from automating the scheduling process through the use of an optimization model.

D. CPSKED SOLUTION STRATEGY

CPSKED is an optimization scheduling tool developed and implemented as a set covering model. "Optimization" increases the model's power as a decision

support system and "set covering" provides model flexibility and precision. Large-scale set covering models, despite their advantages, are generally considered difficult or impossible to solve. This section provides the rationale, based on modeling concepts and experience gained from prior research, for selecting this approach to solve the primary event scheduling problem.

Because of their combinatorial nature, scheduling problems are difficult to solve optimally. Consequently, many suboptimal, heuristic techniques have been developed for attacking scheduling problems. However, optimization should be preferred over suboptimal techniques because optimal solutions provide a proper reference for judging the acceptability of all alternative schedules. Geoffrion and Powers [Ref. 2] have stated the need for optimization:

> The problem is not that optimization capability is needed to cope with the staggering number of alternatives...although this is important. It is not that optimization capability is needed to resolve the cost trade-offs inherent in planning, although this too is important. It is not even that managers would rather have the best answers possible from their planning support systems, although certainly this is compelling. Rather, the crux of the matter is that optimization capability is needed to permit reliable comparisons between different runs of the model.

Therefore, the goal of this study is to develop a model and solution techniques that reliably provide optimal solutions to the CPSKED problem.

Scheduling problems can frequently be viewed as selection models, e.g., route selection, crew selection, etc. In the CPSKED problem, a set of individual ship schedules must be selected such that demands for ship-types and weapon system capabilities required by different events are satisfied. Selection problems may be formulated as set covering or set partitioning problems. In terms of a scheduling problem, the objective of a set covering model is to select a minimum cost set of schedules such that all demands for service are at least minimally

satisfied or "covered." When the problem constraints are stated as equalities, i.e., demands must be satisfied exactly, the problem is referred to as a "set partitioning" or "equality constrained set covering" problem. The CPSKED problem is formulated here as a set covering problem with certain generalizations.

In the CPSKED problem, variables correspond to individual ship schedules and constraints correspond to primary event requirements. Event requirements are stated in terms of force composition (ship-types) and force weapon system capabilities. The basic development of the model is discussed in Chapter III.

Set covering problems represent a class of integer programming problems which is simple in concept. Unfortunately, like most integer programming problems, set covering problems are quite difficult to solve. However, recent advances in solution techniques have made possible the solution of large problems. (See Bausch [Ref. 3] for a survey of these computational advances.) Brown, Graves, and Ronen [Ref. 4] have applied the set partitioning model to a crude oil ocean tanker scheduling problem. Their large-scale problems (74 constraints and greater than 7,000 binary variables) were typically solved in less than one minute of IBM 3033 CPU time. Their success is based on the X System [Ref. 5] which is an advanced general purpose optimization system. Since this system is available at the Naval Postgraduate School, it is employed as the solver for the CPSKED set covering problem.

The set covering approach allows many of the real-world modeling constraints to be included in problem generator versus the problem solver. This allows for flexible and precise modeling. Essentially, the problem generator generates columns of the integer programming constraint matrix, each of which corresponds to a feasible schedule. As Bausch [Ref. 3] states "The art of

formulating practical set covering problems lies in the schemes used for column generation." Details of the problem generation scheme are given in Chapter IV.

The development of this model requires a method for evaluating each ship schedule in terms of the employment scheduling objectives. Commercial ship scheduling and/or routing models typically address distances, speeds, profits, capacities, etc. The CPSKED problem is concerned with more abstract military objectives, readiness and operational effectiveness. Appropriate surrogate objectives that provide the best opportunity to maximize the real, but abstract, objective are often used both in modeling and in reality. CINCLANTFLT's scheduling policy guidelines are in fact surrogate objectives designed to provide each unit the best opportunity to maximize the real objective, combat readiness. Precedence for the use of surrogate objectives in modeling also exist. Sibre [Ref. 5] employs surrogate objectives in place of abstract military objectives in his study of a U. S. Coast Guard ship scheduling problem. In that study, Sibre used a quadratic assignment model with morale-related objectives in terms of "away from home port time", "balanced workload", and "maximum single cruise duration." In this study, military objectives are developed in terms of scheduling policies as they relate to fleet readiness (see Chapter II) and are implemented using techniques based on goal programming methods [Ref. 6].

E. THESIS OUTLINE

This study presents a set covering optimization model for solving the CPSKED problem. In Chapter II, the problem is defined in detail and measures of effectiveness are developed. Chapter III develops the set covering solution method. The method used to generate the problem is described in Chapter IV. In Chapter V, the model is implemented using data from the 1983

CINCLANTFLT schedule; the results are then compared with the actual 1983 CINCLANTFLT schedule. Conclusions and recommendations are summarized in Chapter VI.

II. PROBLEM DEFINITION

Industrial production problems are often concerned with maximizing productivity subject to constrained resources. The Navy employment scheduling problem closely parallels the industrial problem, i.e., the Navy is concerned with maximizing national defense subject to constrained fleet resources. Analysis of an industrial production problem requires a working knowledge of the company's management goals and procedures; similarly, analysis of the Navy employment scheduling problem requires a knowledge of the Navy's management goals and procedures. This chapter provides a brief background in Navy management and planning concepts. The insight provided by this background information is used to isolate a moderate- sized, independent subproblem (CPSKED) from the overall scheduling problem and to develop specific measures of effectiveness for this subproblem.

A. NAVY MANAGEMENT AND PLANNING CONCEPTS

Navy management and planning concepts are contained in NWP-1 [Ref. 1], NWP-7 [Ref. 7], and Atlantic Fleet Regulations [Ref. 8]. The background provided in this section is divided into the following four areas: management and control of operating forces; employment schedule events; fleet assets and employment cycles; and planning policy.

1. Management and Control of Operating Forces

Navy organization distinguishes between two types of control for its operating forces: administrative control (ADCON) and operational control

(OPCON). Administrative control is concerned with training, maintenance, and readiness while operational control is concerned with conducting naval operations and exercises. All Navy operating forces are assigned to either the Atlantic or Pacific Fleet Commanders for administrative control. The Fleet Commanders normally delegate administrative control to Type Commanders. Operational control is exercised by Unified Commanders (CINCs) and is normally delegated through Naval Component Commanders (FLTCINCs) to Operational Fleet Commanders (OPFLTs) or Type Commanders.

Operational control of an Atlantic Fleet unit is transferred to CINCUSNAVEUR or CINCPACFLT when the unit is operating away from the home fleet. Operational control of units operating in the home fleet is normally delegated to COMSECONDFLEET, OPFLT in the Atlantic. Administrative control of Atlantic Fleet units is delegated to the Type Commanders: COMNAVSURFLANT for surface ships, COMNAVAIRLANT for aircraft carriers and air squadrons, COMSUBLANT for submarines, and FMFLANT for marine units.

The Atlantic Fleet Employment Schedule provides detailed information on the utilization and status of naval forces. The schedule is published quarterly and consists of a detailed quarterly schedule and an annual planning schedule. The detailed quarterly schedule contains all tasks and activities to be conducted by fleet units and is directive in nature. The annual planning schedule contains only major activities and is informative in nature. The quarterly schedule must account for every day in the quarter for each unit; the annual planning schedule need not account for each day in the year.

The Employment Schedule is a primary management tool for both planning and control of fleet units. As administrative commanders, the Type

Commanders develop the major portions of these schedules. CINCLANTFLT coordinates, approves, and promulgates the schedule. This study is concerned with the annual planning schedule.

2. Employment Schedule Events

The tasks and activities contained in the Employment Schedule are broken down into 27 categories which are further subdivided into specific employment terms (EMPTERMs). A complete description of categories and terms may be found in NWP-7 [Ref. 12]. In this study, the term "event" is used to refer to a collection of EMPTERMs related to the same task. Events are categorized as either primary events, major maintenance events, or secondary events.

Primary events consist of extended operations and major exercises. These events are the backbone of the schedule. Primary events result from fleet operational commitments, e.g., commitments to deploy a battle group to the Indian Ocean, or commitments to participate in a specific NATO exercise. These events are fixed in time, i.e., they have fixed start and completion times.

Major maintenance events, e.g., construction, conversion, overhaul, etc., are dependent on shipyard availability and ship cycles. These events are generally scheduled independently of all other events. Units scheduled for major maintenance events are not considered available for primary events.

Secondary events include the remaining events associated with maintenance, training, inspections and other individual unit events. Secondary events may be viewed as preparation and support for the primary events. These events are generally scheduled not to conflict with the primary events.

This study develops and implements a method for producing annual planning schedules for the primary events. Non-operational periods resulting from major maintenance events are presumed known and sufficient time is set aside in the primary event schedule to permit subsequent scheduling of secondary events.

3. Fleet Assets and Employment Cycles

Fleet assets are classified in functional categories as combatant ships, amphibious ships, service ships, submarines, aircraft units, fleet marine units, training units, and shore support units. Within each functional category, unit operational requirements are similar; consequently, units may exchange roles within certain limits, e.g., a frigate may be able to fill the a requirement for a destroyer. Capabilities of units in different functional categories are radically different with respect to primary events and unit substitution across functional boundaries is not acceptable.

Fleet assets are further classified as either COR (Command Operationally Ready) or CNOR (Command Not Operationally Ready). COR units are capable of participating in "...operational tasks which contribute to the effective accomplishment of the FLTCINC's responsibilities. Commands that are CNOR are assigned to the OPCON of the Type Commander who is responsible for conducting the training and maintenance required for the unit to attain COR status." Only COR assets can be assigned to primary events. A fleet unit's status is primarily dependent on its employment cycle. The ship employment cycle is defined in NWP-1 [Ref. 1] and consists of the following phases: the new construction or overhaul phase, the operational phase, and the refit phase. A new cycle begins each time the ship enters overhaul. A ship is COR only during the operational phase.

The operational phase consists of four periods: the ready period, the preparation for overseas movement (POM) period, the deployed period, and the post deployment leave period. During the ready period, the ship will be under the operational control of COMSECONDFLEET and participate in home fleet operations and exercises. During the POM and post deployment leave periods the ship remains in its home port. Any period in which the ship operates away from home port for more than eight weeks is considered a deployed period.

4. Schedule Planning Policy

Schedule planning policy is described in Atlantic Fleet Regulations [Ref. 8]. The stated objective for CINCLANTFLT policy is to "...maintain the Fleet at the highest level of readiness for: (1) Operations in the Atlantic; and (2) to ensure that individual units are fully ready for projected employment when deployed." This policy establishes "...firm scheduling criteria to provide for basic type training, allow for adequate ship maintenance, and ensure reasonable time in home port." Those policy guidelines that are pertinent to this study are summarized below:

a. Normally, not more than one third of the time between overhauls shall be committed to deployments.

b. Ten days per quarter shall be available to each ship for the conduct of individual ship training.

c. Following extended operations, ships will be scheduled for a period of 15-30 days post deployment leave.

d. Ships will normally be assigned 20 working days of upkeep per quarter.

e. Ships scheduled for extended operations will be scheduled for a POM period of three to four weeks duration just prior to deployment.

f. Ships in the operational phase will normally be scheduled for an optimum of 30 operating (at-sea) days per quarter.

g. To the extent possible, employment schedules will provide each ship an average of 40 percent time in home port between overhauls.

B. THE CPSKED PROBLEM

The overall employment scheduling problem involves scheduling primary, secondary, and major maintenance events for all operating forces in the Atlantic Fleet. Several independent subproblems may be identified in the overall employment scheduling problem. Divisions can be made in terms of fleet assets and event types. The CPSKED problem is an example of one of the possible independent subproblems.

1. Division by Fleet Assets

As mentioned earlier in this chapter, fleet assets include a wide variety of units performing very different functions. With respect to primary event scheduling, each of these functional categories is independent since a unit in one functional category cannot perform the mission of a unit in a different category. In primary event scheduling, mission capability is the primary consideration and the primary event scheduling problem can be divided into subproblems by functional category.

2. Division by Event Types

Major maintenance events are dependent on a unit's employment cycle and are scheduled based on shipyard availability and optimum maintenance cycles. Major maintenance schedules are developed prior to scheduling other events. Units scheduled for major maintenance become non-operational (CNOR) assets; thus, the effect of scheduling major maintenance is to limit the quantity of available operational assets for subsequent primary event employment scheduling.

Primary events are the "end products" of all fleet activity during peacetime and receive the highest priority when scheduling operational fleet assets. Primary event requirements cannot be satisfied by CNOR assets.

Secondary events are scheduled by individual units after primary event requirements have been satisfied. Secondary events are unit maintenance, training, and exercise events necessary to maintain unit readiness to support fleet operations.

Division of the overall scheduling problem by event types leads to a hierarchical ordering of the overall scheduling problems. First, solve the major maintenance scheduling problem and determine operational unit availability. Second, solve the primary event scheduling problem. Third, solve the secondary event scheduling problem using the remaining unscheduled time.

3. Primary Event Scheduling Problems

Primary event scheduling problems exist for each of the functional categories. For model development, the combatant functional category is used (thus, CPSKED for Combatant Primary Schedule); however, the resulting model may be adapted to any of the remaining functional categories.

The two major assumptions underlying primary event scheduling problems are: (1) the major maintenance schedule is known, and thus, operational asset availability is also known, and (2) the primary events are commitments that are fixed in start time and duration. The problem then becomes one of optimally assigning operational assets to satisfy primary event requirements.

C. MEASURES OF EFFECTIVENESS (MOEs)

Optimization implies the existence of a measurable criterion that is to be maximized or minimized. In the overall employment scheduling problem the stated objective is to "maintain the highest level of readiness." In recognition of

the fact that readiness is a difficult entity to measure, Navy policy defines the following as significant factors supporting fleet readiness: effective deployment of forces, maintenance, training, and personnel morale.

In the broad sense, effective deployment of forces means satisfying the primary event requirements. Decisions to commit forces to operations and exercises at home and abroad are made at the highest levels with careful consideration for their contribution to overall military readiness. Thus, effective deployment of forces is accomplished by prescribing the primary event requirements, in terms of force composition and capability, which are then converted to problem constraints. These constraints must be satisfied at the sacrifice of the remaining factors.

The remaining three major factors, maintenance, training, and personnel morale, are difficult to measure directly, and hence, more concrete MOEs that provide the opportunity to achieve these criteria are sought. The CINCLANTFLT scheduling policies described earlier in this chapter are guidelines or goals designed to maximize the opportunity for each unit to achieve the highest degree of readiness in maintenance, training, and personnel morale.

During the operational phase, CINCLANTFLT policy states that 20 working days per quarter should be assigned for maintenance upkeep. For the CPSKED problem, this implies that at least one third of the home fleet time should be reserved for in-port upkeep.

To maintain training readiness, CINCLANTFLT policy states that ten days per quarter should be provided for each ship to conduct individual ship training (ISE). ISE periods are considered secondary events and not scheduled in CPSKED; however, the CPSKED solution should reserve sufficient home fleet at-sea time to satisfy this requirement.

The major factors affecting personnel morale are family separation and crew liberty. To ensure family separation is not excessive and crew liberty is adequate, CINCLANTFLT policy establishes the following guidelines: no more than one third of the time between overhauls should be deployed time; deployments will be followed by a post deployment leave period; and ships in the operational phase should be scheduled for no more than 30 days at-sea per quarter.

A schedule that provides the optimal amount of home port time for training, morale, and maintenance, the optimal amount of home fleet underway exercise time for training, and an equitable deployment rotation of ships will provide the best opportunity to achieve the CINCLANTFLT goals for readiness. Based on this observation, a measurable MOE can be constructed from the CINCLANTFLT policy guidelines.

The approach is a *goal – programming* technique. Policy statements are used to derive ideal *target* times, or goals, for deployment time, home fleet at-sea time, and deployment rotation time. Home fleet time consists of the operational phase time less deployment time. Home port time is the home fleet time less the home fleet at-sea time. Assuming all constraints can be satisfied, the objective becomes: minimize the deviations from the ideal target times and the single MOE is a function of the deviations from the target times. If some of the constraints cannot be satisfied, constraint violation penalties, discussed in the next chapter, are included in the objective.

This objective captures the intent of the CINCLANTFLT policy guidelines; however, it cannot measure many of the intangible factors that must be considered when developing an employment schedule. Neither can the intangible

factors always be included as problem constraints. On the other hand, a human scheduler cannot possibly evaluate all scheduling alternatives to determine an optimum schedule. A human scheduler is required to ensure "all" criteria are satisfied; the optimization model is required to ensure the resulting schedule is the "best" schedule in terms of the established criteria.

The CPSKED problem may now be stated as follows: Generate an annual planning schedule for all carriers and surface combatants that minimizes the deviations from the fleet's ideal schedule (specified by target deployment time, home fleet at-sea time, and deployment rotation time) while satisfying, as best possible, all primary event requirements.

III. MODEL DESCRIPTION

This chapter presents the rationale for modeling the CPSKED problem as a set covering problem. The set covering model and generalizations are discussed and the CPSKED model is developed as an elastic set covering model. The objective function costs and penalties are developed in terms of the CINCLANTFLT policy described in the previous chapter.

A. MODEL SELECTION

Many types of scheduling problems may be solved as set covering or set partitioning problems. The basic formulation is straightforward; however, for practical problems, these formulations typically result in thousands of variables and are considered difficult to solve optimally. For this reason, approximate heuristic methods have been used extensively in solving these problems. Fortunately, a sophisticated large-scale mixed integer linear programming solver, the X System [Ref. 9], permits the efficient solution of many large-scale problems. Bausch [Ref. 3] employed the X System on test problems consisting of several hundred constraints and thousands of variables in his survey of computational techniques for solving large-scale set covering problems; the results were quite favorable. The crude oil tanker problem, Brown, Graves, and Ronen [Ref. 4], in which columns represent possible ship routes and the object is to select the least cost set of routes, contained thousands of variables and was solved using the X System in less than one minute of IBM 3033 CPU time.

Official Navy policy states that "The optimized peacetime employment schedule which has as its objective maximizing combat readiness should always

be the goal and guide." [Ref. 1] Thus schedule optimization is a Navy goal. The existence of a sophisticated, proven, large-scale solver allows formulation of the CPSKED problem as a set covering problem with high expectation of achieving optimal solutions.

B. THE SET COVERING MODEL

Set covering models formulated as integer linear programs have been known and proposed for practical applications for many years. The standard formulation is:

$$\min \sum_{j=1}^{J} c_j x_j$$

$$\text{s.t.} \sum_{j=1}^{J} a_{ij} x_j \geq b_i \qquad i = 1, \ldots, I$$

$$x_j \in \{0,1\} \quad j = 1, \ldots, J$$

where

$a_{ij} \in \{0,1\}$, and $b_i > 0$ and integer.

In this formulation, a minimum cost set of columns from the constraint matrix must be chosen such that that each constraint is satisfied, i.e., "covered" at least b_i times.

In many practical applications, the columns may be partitioned into sets where only one column per set is allowed. For example, a set may consist of all possible schedules for a single ship and exactly one of the schedules in the set must be selected. If there are K such sets, $S_1, \ldots, S_K$, the model may be generalized to admit only one column per set in the final solution. This is accomplished by adding the following constraints:

$$\sum_{j=1}^{J} \delta_{kj} x_j = 1 \quad k = 1, \ldots, K$$

where

$$\delta_{kj} = \begin{cases} 1 & \text{if } j \in S_k \\ 0 & \text{otherwise.} \end{cases}$$

The standard formulation may be generalized to admit ranges on the constraints. This generalized set covering problem is:

$$\min \sum_{j=1}^{J} c_j x_j$$

$$\text{s.t.} \sum_{j=1}^{J} \delta_{kj} x_j = 1 \qquad k = 1, \ldots, K$$

$$b_i^- \leqslant \sum_{j=1}^{J} a_{ij} x_j \leqslant b_i^+ \quad i = 1, \ldots, I$$

where

$$b_i^+ \geqslant b_i^- > 0.$$

Note that equality constrained set covering problems, i.e., set partitioning problems, can be formulated this way by setting $b_i^+ = b_i^-$ for all i.

Efficient, reliable solution of set covering models is difficult. The X System is an advanced general purpose large-scale optimization system with special features for solving integer and mixed-integer models. This system employs "elastic" programming techniques [Ref. 10]. Elastic programming assumes that all constraints may be violated at a cost. This technique allows the feasible region to be "stretched," subject to penalty costs, and generally results in more rapid convergence to an optimal integer solution. In an elastic formulation, feasible solutions always exist; the objective, then, is to find a feasible solution that minimizes both the original objective and the sum of the elastic penalties.

The elastic formulation of the generalized set-covering problem is:

$$\min \sum_{j=1}^{J} c_j x_j + \sum_{k=1}^{K} (p_k^- s_k^- + p_k^+ s_k^-) + \sum_{i=1}^{I} (p_i^- s_i^- + p_i^+ s_i^+)$$

$$\text{s. t. } 1 - s_k^- \leqslant \sum_{j=1}^{J} \delta_{kj} x_j \leqslant 1 + s_k^+ \qquad k = 1, \ldots, K.$$

$$b_i^- - s_i^- \leqslant \sum_{j=1}^{J} a_{ij} x_j \leqslant b_i^+ + s_i^+ \qquad i = 1, \ldots, I.$$

$$x_j \in \{0,1\} \qquad j = 1, \ldots, J$$

$$s_k^- \geqslant 0, \; s_k^+ \geqslant 0, \text{ and integer} \qquad k = 1, \ldots, K$$

$$s_i^- \geqslant 0, \; s_i^+ \geqslant 0, \text{ and integer.} \qquad i = 1, \ldots, I$$

where

p_k^+, p_i^+ = upper constraint violation penalties

p_k^-, p_i^- = lower constraint violation penalties

b_i^+ = upper constraint limit

b_i^- = lower constraint limit.

C. CPSKED PROBLEM FORMULATION

The CPSKED problem is formulated as a generalized elastic set covering problem using the following notation:

Indicies:

$k = 1, \ldots, K$	(rows) constraints requiring that one schedule column be selected for each ship,
$i = 1, \ldots, I$	(rows) event/ship-type requirements,
$l = 1, \ldots, L$	(rows) event/ weapon system capability requirements,

$j = 1, \ldots, J$	(columns) each representing an individual ship schedule,
$p = 1, \ldots, P$	primary schedule events,
$q = 1, \ldots, Q$	ship-types,
$w = 1, \ldots, W$	weapon system types,
S_k	index set identifying all schedule columns belonging to ship k,
R_p	index set identifying all event/ship-type requirements belonging to event p,
R_q	index set identifying all event/ship-type requirements requiring ship-type q,
V_p	index set identifying all weapon system capability requirements belonging for event p
V_w	index set identifying all weapon system capability requirements requiring weapon system type w.

Data:

c_j, $j \in S_k$	cost of schedule j for ship k.
δ_{kj}, $j \in S_k$, $k = 1, \ldots, K$	1 if schedule j is for ship k; 0 otherwise,
a_{ij}, $j \in S_k$, $i \in R_p \bigcap R_q$	1 if schedule j assigns ship k to event p as ship-type q; 0 otherwise,
λ_{lj}, $j \in S_k$, $l \in V_p \bigcap V_w$	1 if ship k has weapon system w; 0 otherwise,
b_i^-, $i \in R_p \bigcap R_q$	minimum number of ships of type q required for event p,

b_i^+, $i \in R_p \bigcap R_q$	maximum number of ships of type q allowed for event p,
b_l^-, $l \in V_p \bigcap V_w$	minimum number of weapon systems of type w required for event p,
b_l^+, $l \in V_p \bigcap V_w$	maximum number of weapon systems of type w allowed for event p,
p_k^-, $k = 1, \ldots, K$	penalty for not scheduling ship k,
p_k^+, $k = 1, \ldots, K$	penalty for assigning more than one schedule to ship k,
p_i^-, $i \in R_p \bigcap R_q$	per unit penalty for assigning too few ships of type q to event p,
p_i^+, $i \in R_p \bigcap R_q$	per unit penalty for assigning too many ships of type q to event p,
p_l^-, $l \in V_p \bigcap V_w$	per unit penalty for assigning too few weapon systems of type w to event p,
p_l^+, $l \in V_p \bigcap V_w$	per unit penalty for assigning too many weapon systems of type w to event p.

Decision Variable:

x_j	1 if schedule j is selected; 0 otherwise.

Logical Variables:

s_k^+, $k = 1, \ldots, K$	greater than 1 if more than one schedule is selected for ship k; 0 otherwise,
s_k^-, $k = 1, \ldots, K$	1 if no schedule is selected for ship k; 0 otherwise,
s_i^+, $i = 1, \ldots, I$	amount by which b_i^+ is violated,

s_i^-, $i = 1, \ldots, I$ — amount by which b_i^- is violated,

s_l^+, $l = 1, \ldots, L$ — amount by which b_l^+ is violated,

s_l^-, $l = 1, \ldots, L$ — amount by which b_l^- is violated.

Formulation:

$$\min \sum_{j=1}^{J} c_j x_j + \sum_{k=1}^{K} (p_k^- s_k^- + p_k^+ s_k^+) + \sum_{i=1}^{I} (p_i^- s_i^- + p_i^+ s_i^+) + \sum_{l=1}^{L} (p_l^- s_l^- + p_l^+ s_l^+)$$

$$\text{s. t. } 1 - s_k^- \leqslant \sum_{j=1}^{J} \delta_{kj} x_j \leqslant 1 + s_k^+ \qquad k = 1, \ldots, K$$

$$b_i^- - s_i^- \leqslant \sum_{j=1}^{J} a_{ij} x_j \leqslant b_i^+ + s_i^+ \qquad i = 1, \ldots, I$$

$$b_l^- - s_l^- \leqslant \sum_{j=1}^{J} \lambda_{lj} x_j \leqslant b_l^+ + s_l^+ \qquad l = 1, \ldots, L$$

$$x_j \in \{0,1\} \qquad j = 1, \ldots, J$$

In words, the model is interpreted as: "Choose the minimum cost set of ship schedules such that one schedule per ship is included in the set and most (ideally all) event requirements are satisfied." To produce meaningful planning schedules, the costs and penalty structures are critical to the model. These topics are the subject of the next two sections.

D. SCHEDULE COSTS

This section details the computation of the costs for individual ship schedules, i.e., the c_j values of the CPSKED model. The objective for the CPSKED model is to satisfy the event requirements while providing an equitable rotation of the ships between deployed and home fleet status and providing an

even distribution of the home fleet workload. This objective is decomposed into the following three components based on CINCLANTFLT policy goals:

1. Achieve an ideal time between successive deployments for an individual ship.
2. Maintain an ideal ratio of a ship's deployment time to between overhaul time.
3. Maintain an ideal ratio of a ship's home fleet sea time to home fleet total time.

The first two objectives replace the "equitable rotation" requirement while the third replaces the "even workload" requirement.

Under the model assumptions, an employment schedule that satisfies the event requirements while achieving the ideal times and ratios specified is considered an ideal schedule. Given the ship assets and event requirements for the Atlantic fleet, the likelihood of achieving an ideal schedule is extremely small. To obtain a schedule as close as possible to the ideal, a cost structure measuring the deviations from the ideal schedule is imposed on the problem. The following targets are established for all ships:

T_1 time (in days) between deployments,

τ_2 target ratio of deployed days to between overhaul days,

T_2 deployment time (in days) required to achieve ratio τ_2,

τ_3 target ratio of home fleet sea days to total home fleet days,

T_3 home fleet sea time (in days) required to achieve ratio τ_3

Costs C_{1j}, C_{2j}, and C_{3j} with respect to a particular schedule j are then defined in terms of the targets as follows:

$$C_{1j} = \begin{cases} 0.1 \times (\text{ deviation above } T_1) \\ 1.0 \times (\text{ deviation below } T_1), \end{cases}$$

$$C_{2j} = \begin{cases} 1.0 \times (\text{ deviation above } T_2) \\ 0.1 \times (\text{ deviation below } T_2), \end{cases}$$

$$C_{3j} = \begin{cases} 1.0 \times (\text{ deviation above } T_3) \\ 0.25 \times (\text{ deviation below } T_3). \end{cases}$$

The costs here are functions of deviation in days from the target. In terms of CINCLANTFLT policy, it is more costly to over-employ a unit rather than under-employ a unit. Consequently, costs are relatively reduced when they reflect under-employment of a unit, i.e., more time between deployments, less deployed time, or less home fleet sea time.

The *linear cost* of a schedule j is defined to be the sum of the three cost functions :

$$C_j = C_{1j} + C_{2j} + C_{3j}.$$

This column cost is intuitively appealing since it can be viewed as a measure of the total deviation in days from an ideal schedule for a particular ship. The sum of the linear costs over all ships indicates a measure of the deviation in days for the fleet employment schedule from an ideal schedule.

Frequently there will be insufficient assets of a given ship-type to satisfy the event requirements. When this occurs, ships of a different type are generally substituted to satisfy the shortfall. The acceptability of ship substitutions depends on the mission requirements for the given event. In this model, substitutions are allowed at an increased cost. Acceptable substitutions are part of the event input data, e.g., for a given event it may be acceptable to substitute an FFG for a DDG with an acceptability factor of 0.8. The acceptability factor is a measure of how well the substituting ship can perform the duties of the

required ship for the particular event and lies in the range (0,1]. The acceptability factor is used to adjust the linear cost of a schedule column containing substitution assignments. If there are no substitutions, the acceptability factor is considered to be 1.0 and the linear cost for the column is as described above. If there are substitutions, then the linear column cost is divided by the average of the acceptability factors for the events contained in the schedule column. Then, for two similar columns, one with substitutions and one without, the costs of the column with substitutions will be greater with the amount of the difference a function of the acceptability of the substitution. This procedure allows the model to discriminate between substitutions and primary assets and keeps substitutions to a minimum level.

Though appealing, the linear cost, adjusted for substitutions, may result in poor decisions if used directly in the model. The problem is illustrated by the following example:

> Suppose ships A and B have schedules with costs of 50 and 50 respectively. If ship A and B also have schedule columns with costs 0 and 100 respectively which satisfy the same combined set of event requirements, then the model will not differentiate a preference between the first cover (cost 100) or the second cover (cost 100). Part of the scheduling objective is to distribute the workload equitably over all fleet assets, hence, when costs are equal, the model should be capable of selecting the cover that distributes the costs over the most ships.

To avoid this problem, the squares of the adjusted linear costs are used in the model. This cost allows the model to resolve ties by spreading the cost over the greater number of ships.

All components of a ship's column cost are computed with regard to the ship's current employment cycle. This requires a knowledge of the following historical information for each ship:

D_1 total days in the current operational phase,
D_2 total deployed days in the current operational phase,
D_3 total home fleet sea days in the current operational phase,
D_4 last deployment completion date.

The cutoff date for this information is the last day prior to the model planning period. If a ship has not deployed since beginning its operational phase, its last deployment completion date is set to the date the ship last completed overhaul or was commissioned.

Column cost computation is described in the following equations:

Terms:

c_j model column cost,
C_j linear column cost,
C_{1j} time between deployment cost,
C_{2j} deployment cost,
C_{3j} home fleet sea cost,
α_{ij} substitution acceptability factor,
$\overline{\alpha}_j$ column average acceptability factor,
t_1 time between deployments,
t_{2i} deploy time for event i,
t_{3i} home fleet sea time for event i,
T_1 time between deployment target,
T_2 deploy time target,
T_3 home fleet sea time target,
τ_2 deploy time target ratio,
τ_3 home fleet sea time target ratio,
D_1 starting total days in operational phase,
D_2 starting total deployed days,
D_3 starting total home fleet sea days,
D_4 last deployment completion date,

d_1 total days in operational phase,
d_2 total deployed days,
d_3 total home fleet sea days,
d_4 last deployment completion date,

N ship non-operational days for the planning period (generally overhaul periods),

X slack operating days for ship-type training and individual ship exercises.

Counters:

$$d_1 = D_1 + 365 - N$$

$$d_2 = D_2 + t_{2i}$$

$$d_3 = D_3 + t_{3i} \ .$$

Targets:

$T_1 = 360$ (may be varied for each ship-type)

$$T_2 = \tau_2 d_1$$

$$T_3 = \tau_3 (d_1 - d_2) \ .$$

Cost formulas:

$$C_{1j} = \begin{cases} 0.1(T_1 - t_1) & \text{if } T_1 \geq t_1, \\ t_1 - T_1 & \text{if } T_1 < t_1, \\ 0 & \text{if event is in progress at the beginning of the planning period.} \end{cases}$$

$$C_{2j} = \begin{cases} T_2 - d_2 & \text{if } T_2 \geq d_2, \\ 0.1(d_2 - T_2) & \text{if } T_2 < d_2. \end{cases}$$

$$C_{3j} = \begin{cases} T_3 - d_3 & \text{if } T_3 \geq d_3, \\ 0.25(d_3 - T_3) & \text{if } T_3 < d_3. \end{cases}$$

$$\bar{\alpha}_j = \sum_{i : a_{ij} \neq 0} \alpha_{ij} \ / \ \sum_i a_{ij}$$

$$C_j = (C_{1j} + C_{2j} + C_{3j}) \ / \ \bar{\alpha}_j$$

$$c_j = C_j^2$$

E. PENALTIES

In the elastic formulation of the model, penalties can be categorized as either model disruption penalties or goal violation penalties. When violation of an inelastic constraint has no physical interpretation, the penalty for violating the constraint is a model disruption penalty; these penalties should be sufficiently small to allow reasonable relaxation of the feasible region, yet great enough to enforce the constraint in the final solution. When a constraint can be violated at a cost in the final solution, the constraint is actually a goal and the penalty is a goal violation penalty.

In the CPSKED problem, the first set of constraints require that exactly one schedule column be selected for each ship. The second set of constraints requires that the correct force composition be assigned for each event. The third set of constraints requires that correct set of weapon system capabilities is assigned for each event. The associated ranges and penalties for these sets of constraints are assessed separately.

1. Ship-Schedule Constraints

Since exactly one schedule is desired for each ship, the upper and lower ranges on the ship-schedule constraints are both set to one. Violation of the upper range implies that a ship would receive more than one schedule for the planning period. A ship cannot be employed in different locations simultaneously; hence, the upper range must not be violated in the final solution. The penalty then is a model disruption penalty that increases problem elasticity while enforcing the upper range on the constraint. A ship schedule cost is measured in terms of days deviation from an ideal ship schedule. Schedule costs beyond a certain limit, typically 200-300 days deviation, would be

counterproductive to maintaining a high state of combat readiness. An upper bound on this limit of 1000 days deviation is used to establish the model disruption penalty. The CPSKED objective function is in terms of days deviation squared, thus the penalties must also be in days deviation squared and the resulting penalty is 1.0×10^6 days deviation squared. Any combination of columns for a particular ship will cost more, including penalty, than any single column for the ship and consequently, multiple schedules will not be selected in any optimal solution.

Violation of the lower range on a ship-schedule constraint corresponds to not scheduling that ship. The lower penalty, then, should be the price at which it is acceptable to allow the ship to remain idle throughout the planning period. In the CPSKED model, the "idle" price is computed for each ship, this price is equivalent to the column cost for a "do nothing" column. The "idle" price squared is then used as the penalty for violating the lower range of the ship-schedule constraints.

2. Event Requirement Constraints

In the CPSKED model, the events are CINCLANTFLT commitments and the event requirement constraints can be interpreted as goals to meet those commitments. It may not be possible to meet these goals at any reasonable cost. The penalties associated with these constraints are goal violation penalties.

The lower range b_i^- on an event requirement constraint corresponds to the minimum number of ships of a particular type required for the event. Event values are assumed to be related to the event duration and deployment status. Generally, short home fleet sea events are more easily canceled or rescheduled than long duration deployed events and consequently receive a lesser value in the

schedule planning process. In the CPSKED model the event values are defined to be the duration of the home fleet sea days and/or the deployed days contained in the event. The lower penalty p_i^- is a price above which the cost of committing additional assets to the event exceeds the value of the contribution of those assets. In this model, the lower penalty is a function of the event value and may be adjusted within the program.

Situations arise where a ship would be under-employed if all minimum event requirements b_i^- are met exactly. Under these circumstances, it may be desirable to schedule the ship for some events in excess of minimum event requirements in order to maintain training and proficiency for the ship. To allow for this possibility, the upper range b_i^+ for all event requirements may be set above the minimum requirement. In most instances, ship assets will be in short supply and the lower range will be binding. The upper penalty p_i^+, in effect when the upper range is exceeded, is a function of the event value and may be adjusted within the program.

3. Force Weapon System Capability Constraints

Frequently, primary events may require a specified set of force weapon system capabilities. Weapon system capabilities are not necessarily unique to ship types and hence, the force system capability requirements may be satisfied by various mixes of ships. Penalties for violating these constraints are related to the additional value a particular weapon system contributes to an event's mission and consequently should be input data under the scheduler's control. These penalties should be high enough to enforce the constraints but less than event/ship-type penalties since a weapon system contributes less than an entire unit to the event's mission. In this prototypic implementation, these penalties

were all set to 1,000 (lower) and 0 (upper). These penalties worked well in the model; however, a more thorough knowledge of mission requirements and system contributions would enable improvements.

IV. PROBLEM GENERATION

Solving the CPSKED problem consists of four steps; problem formulation, problem generation, problem solving, and report writing. In this chapter, the second step, problem generation is discussed. In the set covering formulation each of the variables represents a candidate schedule. A primary advantage of this formulation is that only those schedules that are viable need be included in the problem, e.g., time restrictions, cost limits and other real-world constraints may be used in the problem generator to reduce the size of the problem sent to the solver. In a complete set covering problem with m inequality constraints, there are $2^m - 1$ variables or columns. Complete set covering problems rapidly become very large and consequently become difficult or impossible to solve even with the best of solvers. In practical applications, many columns in the complete set will have no usable real-world interpretation with respect to the application. Other columns may violate restrictions on time, speed, distance, costs, etc. To reduce the size of the problem that is ultimately sent to the solver, the column generator should incorporate as much of the column feasibility criteria and real-world restrictions as possible. In the following sections, the techniques used to generate the CPSKED columns are discussed. Since there is a one-to-one correspondence between ship schedules and model columns, the terms "schedule" and "column" are used interchangeably.

A. GENERATING FEASIBLE SCHEDULES

The following three rules are used to determine whether or not a schedule for a particular ship is feasible:

Rule 1. A unit must be of the proper type, or an allowable substitute, to satisfy an event requirement constraint.

Rule 2. A unit may not participate in primary events when the unit is in a non-operational status.

Rule 3. A unit cannot be participate in more than one primary event at any given time.

These rules are used to generate all feasible ship schedule as follows:

For each ship k perform the following steps:

Step 1. Determine the ship-type q and, using rule 1, select all event requirement constraints that demand type q units or allow type q units as substitutions. This "potential ship-event list" is the list of events that ship k could potentially participate in.

Step 2. Determine the ship non-operational periods from input data and, using rule 2, compute the time intersection of each event in the "potential ship-event list" with the non-operational periods. If the time intersection is not null, delete the event from the "potential ship-event list." The resulting list is the "ship-event list."

Step 3. Construct a schedule network as follows: Define a starting node, s, and connect this node to all events in the ship-event list. Using rule 3, connect additional arcs between event pairs if the time intersection of the events in the pair is null; the direction of the arc is from the earlier event to the later event.

Step 4. Let v correspond to an event in a schedule, the set of all directed $s-v$ paths for all v in the network corresponds to the set of all feasible schedules for the ship. Enumerate each $s-v$ path j and set column coefficients: (a) $a_{ij}=1$ if i is on the $s-v$ path; (b) $\delta_{kj}=1$; (c) $\lambda_{lj}=1$ if ship k satisfies part of event/weapon system capability requirement l; and (d) 0 otherwise.

In the CPSKED column generation program, event requirement inputs may be specified by either ship-type or ship hull number. When a scheduler knows *a priori* that a ship must participate in a certain event, the requirement should be input by hull number. The column generator then forces all columns for that hull number to contain the event. Additionally, if a type requirement demands

n units and all n units are specified by hull number, then only those units will contain the event in their ship-event network, i.e., only those units will be considered for satisfying the event/ship-type requirement. Thus column reductions will occur if all units for a specific type requirement are specified by hull number. This is equivalent to fixing assignments in the schedule. Events in progress at the beginning of the planning period should be fixed in this manner. Also, any requirements that must be satisfied by a particular unit should be fixed to ensure the desired results and to reduce the size of the problem.

The CPSKED column generator allows ship-type substitutions to be specified, at a cost, for each type requirement. If there are n of the required ship-type and m of the substitution ship-type, then there will be $n+m$ candidates available to satisfy the requirement, and a consequential increase in the number of columns. Allowable substitutions should be used sparingly and only where tactically feasible, e.g., a carrier would never substitute for a frigate and a frigate would probably never substitute for a cruiser. Substitution strategy may have a dramatic effect on the number of feasible columns generated.

B. COLUMN REDUCTION

The number of columns produced by the method described above is much less than the $2^I - 1$ combinations which would be produced by a naive generator. Nevertheless, the number of columns can grow very large. Many of these columns may correspond to unit schedules that are unacceptable because of excessive cost. Excessive cost corresponds to severe over-employment of the unit and is counterproductive to the maintenance of high fleet readiness.

After each schedule column is generated, a cost for that column is computed. The cost represents a measure of the deviation from the ideal

individual ship schedule. For each of the component costs, limits may be established beyond which the schedule is deemed completely unacceptable. If the cost of a column exceeds these limits, it is not included in the problem. The CPSKED column generation program accepts the following limiting parameters by ship-type:

Maximum home fleet sea cost,
Maximum deployment cost,
Maximum time between deployment cost,
Maximum column cost.

If an event requires a specific ship by hull number, then that event becomes mandatory for the ship; the cost limits are ignored for the column that contains only mandatory events. Significant reductions in the number of columns sent to the solver are possible using this cost limiting approach.

V. IMPLEMENTATION AND RESULTS

The CPSKED model has been implemented at the Naval Postgraduate School. Input data for testing this implementation has been extracted from the Atlantic Fleet projected annual schedule for calendar year 1983. The testing results indicate that high quality schedules are produced efficiently. Schedule quality is based on comparisons of the CPSKED schedule and the CINCLANTFLT schedule. Model efficiency is discussed in terms of computational experience based on four model runs.

A. COMPUTER PROGRAMS

The CPSKED model has been implemented on an IBM 3033 AP computer system under the CMS operating system. CPSKED consists of three parts; the column generator, the solver, and the report writer.

1. Problem Generator

The CPSKED problem generator is written in ANSI standard FORTRAN 77 and compiled by IBM VS FORTRAN. The program uses a Ship Data file and an Event Data file for input. The program produces an unformatted file which is read directly by the solution driver; this file represents the CPSKED problem in a compact data format suggested by Bausch [Ref. 3].

2. Problem Solver

The solver consists of a problem driver, XSCOVC, and several subroutines. The X System solver routines are written in Level 66 FORTRAN and compiled by the IBM FORTRAN IV H (Extended) compiler. The solver employs many advanced features including hypersparse data representation,

complete constructive degeneracy resolution, basis factorization, and elastic range constraints. The X System may be tailored to specific models to form the computational foundation for specialized application packages. In this development, the CPSKED programs have not been integrated with the solver to take full advantage of the solver's capabilities. In the CPSKED implementation, the solver generates a compact data file representing the CPSKED solution; this file is used as an input file to the CPSKED report writer. The driver, XSCOVC, also produces a condensed output report containing solution characteristics and computational statistics for the problem solution.

3. Report Writer

The CPSKED report writer is written in ANSI standard FORTRAN 77. The program uses the Ship Data file, Event Data file, and schedule solution file as inputs and produces the following reports:

Ship Statistic Report;
Ship Schedules Report;
Event Force Assignment Report.

Samples of the input data files and the CPSKED reports are included in the Appendices.

B. TEST DATA

The model has been tested using actual data from the Atlantic Fleet for calendar year 1983. Model input consists of a ship data input file and an event data input file. Sample input data files are included as Appendices A and B. Scheduling parameters, or goals, are set within the column generation program.

1. Ship Data

The Atlantic Fleet carrier and surface combatant assets for the calendar year 1983 consisted of the ships listed in Table 1.

TABLE 1

1983 Atlantic Fleet Combatants

	Type	Number
Aircraft Carriers	CV/CVN	9
Guided Missile Cruisers	CG/CGN	14
Guided Missile Destroyers	DDG	23
Destroyers	DD	17
Guided Missile Frigates	FFG	19
Frigates	FF	29
Total		111

Non-operational periods, overhaul etc., and historical data for these assets are known and included in the ship input data file. The requirement to select exactly one schedule for each ships results in 111 schedule selection constraints.

2. Event Data

All extended operations and major exercises involving surface combatant units were extracted from the CINCLANTFLT annual schedule resulting in the event list displayed in Table 2.

A primary event is composed of a collection of sub-events; each of these sub events corresponds to an employment term (EMPTERM) used in the Atlantic Fleet Schedule. Each sub-event is designated as deployed time, home fleet sea time, or home fleet inport time. The primary event, MED 2-83, is used as an example, see Table 3.

TABLE 2.

1983 Primary Event List

Extended Operations	Major Exercises
MED 1-83	COMPTUEX 2-83
IO 1-83	SOLID SHIELD 83
MEF 1-83	OCEAN SAFARI 83
MEF 2-83	COMPTUEX 3-83
SNFL 1-83	COMPTUEX 4-83
IO 2-83	COMPTUEX 1-84
MED 2-83	
MEF 3-83	
SNFL 2-83	
UNITAS	
MEF 4-83	
MED 1-84	

(listed in order of event start time)

TABLE 3.

MED 2-83 Sub-events

	EMPTERM	START	END	CODE
Primary event:	MED 2-83	069	355	
Sub-events:	EXER (Readex 1-83)	069	092	S
	POM	093	122	I
	ENR (Transit)	123	133	D
	OPCON	134	315	D
	ENR (Transit)	316	325	D
	LVUPK (Stand down)	326	355	I

codes: D - Deployed time,
I - Home fleet in port time,
S - Home fleet sea time.

A primary event requires a specific force composition, with possible allowance for substitution of assets. These requirements result in the event/ship-type constraints. Typical requirements, based on the MED 2-83 example, are listed in Table 4.

TABLE 4.

MED 2-83 Ship-Type Requirements

Type	Hull	Substitution	Number
CV/CVN	69	none	1
CG/CGN	any	DDG, α = 0.7	2
DDG	any	DD, α = 0.8	2
DD	any	none	2
FFG	any	FF, α = 0.7	3
FF	any	none	3

Force weapon system capability requirements are based on current requirements for forces deploying to the Mediterranean, Middle East, and Indian Ocean. Typical requirements using the MED 2-83 example are listed in Table 5.

TABLE 5.

MED 2-83 Capability Requirements

System	Number
AAW Missile (SM-1/ER)	2
AAW Missile (SM-1/MR)	4
AAW Radar (SPS-48)	3
Data Link (NTDS)	4
Passive Sonar (TASS/TACTAS)	3
ASW Helicopter (LAMPS)	3
Guns (5in/54)	4

The 1983 primary events result in a total of 73 event/ship-type constraints. Force weapon system capability requirements result in 44 additional constraints.

3. Scheduling Parameters

The parameters listed in Table 6 represent the scheduling policy goals and cost limits used in the model runs. These parameters may be modified in the problem generator.

TABLE 6.

Scheduling Parameters

	CV/CVN	CG/CGN	DDG	DD	FFG	FF
T_1	360	360	360	360	360	360
τ_2	.33	.33	.33	.33	.33	.33
τ_3	.33	.33	.33	.33	.33	.33
Max C_1	120	120	120	120	120	120
Max C_2	180	180	120	120	90	90
Max C_3	90	90	60	60	45	45
Max C_j	300	180	150	150	120	120

C. SCHEDULE QUALITY

CPSKED captures the essence of CINCLANTFLT scheduling policy and provides an optimum schedule with respect to that policy. The objective costs, including penalty costs, indicate the overall quality of a schedule, e.g. a schedule with a total objective value of zero is one that satisfies all requirements and exactly achieves all of the CINCLANTFLT policy goals.

The CINCLANTFLT annual schedule did not contain projected ship assignments for all projected primary events, e.g., UNITAS and several exercises were scheduled with ship assignments indicated "DTMD" for "to be determined." To place the CINCLANTFLT schedule on an equal basis with CPSKED for conducting comparisons, all known CINCLANTFLT ship assignments were fixed and CPSKED was run to optimize the remaining part of the schedule. The

result is CINCLANTFLT's annual schedule with all "DTMDs" optimally assigned. Table 7 lists the schedule summary data used to compare this CINCLANTFLT schedule to the CPSKED schedule.

TABLE 7.

CINCLANTFLT vs. CPSKED

	CINCLANTFLT	CPSKED	% IMPROVEMENT
-Objectives-			
Cost:	1,472,500	446,700	70%
-Penalties-			
-violations-			
Sched selection:	0	0	0%
Event/Ship-type:	0	0	0%
Weapon Capabilities:	11	9	18%
-Unit Costs-			
-mean (std.dev.)-			
Total (C_j):	48.2(57.3)	42.7(49.0)	11%(14%)
TBD (C_{1j}):	44.9(43.9)	34.7(28.9)	23%(34%)
DEP (C_{2j}):	25.9(40.4)	24.5(40.1)	5%(1%)
SEA (C_{3j}):	3.9(4.4)	2.9(3.3)	26%(25%)
-Unit Statistics-			
TBD (target 360):	329(142)	344(103)	5%(27%)
DEP Ratio (target .33):	.33(.10)	.34(.09)	-3%(10%)
SEA Ratio (target .33):	.30(.06)	.30(.05)	0%(16%)

The CPSKED model reflects a 70% improvement in quality and also violates fewer weapon system capability goals. Average individual unit costs are not only reduced, they are spread more equitably over the ships as indicated by reduced standard deviations.

A model can never capture all of the criteria involved in scheduling navy ships and, consequently, the full magnitude of improvement indicated by this

comparison may not be achieved. However, a human scheduler can neither evaluate all of the scheduling combinations considered by the model, nor can he hope to compute measures of effectiveness with any precision. Significant scheduling improvements can be achieved by teaming the human scheduler and the model together.

After making an initial reference run of the model, the human scheduler may add constraints or "what-if" questions to the model by fixing specific event/ship assignments. The model should be run again producing an optimal schedule subject to the newly imposed restrictions. The scheduler must then determine whether the restrictions are justifiable in terms of the increased costs. Thus, inter-run comparisons provide a means for developing optimal schedules and for conducting "what-if" analysis. Geoffrion and Powers remarks on inter-run comparisons with distribution planning models apply here as well.

> It is our repeated observation that the motives for making inter-run comparisons are so overwhelming that, in practice, comparisons ... are made and conclusions drawn even when a heuristic (suboptimal) rather than optimizing procedure is used....The importance of inter-run comparisons should not be underestimated. They are needed to justify conclusions reached with the help of the model by (a) exploring uncertain assumptions, (b) studying the impact of alternative futures, and (c) measuring the performance differences between the leading alternatives. ...If the solver is heuristic in character, such comparisons will be very unreliable because comparing two error-prone solutions greatly magnifies the relative error. [Ref. 2]

The best human schedulers will always produce suboptimal schedules. The quality gap between the CINCLANTFLT and CPSKED schedules indicates considerable room for improvement. Narrowing the gap demands optimization support, such as CPSKED, and results in more efficient utilization of fleet assets.

D. COMPUTATIONAL RESULTS

Computational results are discussed in terms of problem characteristics, problem size, and model execution times. The model was run under the following conditions:

1. CPSKED(NS) without substitutions;
2. CPSKED(SU) with substitutions and unlimited costs;
3. CPSKED(S) with substitutions and cost limits;
4. CPSKED(CLF) with CINCLANTFLT fixed assignments.

Run 1, without substitutions, was made to establish a reference objective value and determine if all events could be satisfied without substitution. Run 2, with selected substitutions and no cost limits was made to demonstrate the reduction in problem size that may be achieved by including cost limit constraints in the problem generator. Run 3 was made to demonstrate the effect of allowing ship-type substitutions. Run 4 includes all fixed assignments from the CINCLANTFLT annual schedule. Results of the runs are summarized in Table 8.

1. Characteristics

In each run there are 111 ship-schedule selection constraints, 73 event/ship-type constraints, and 44 force weapon system capability constraints. There are 105 ships operational for some period during the planning year, the remaining 6 ships are not operational at any time during the year. Events in progress at the beginning of the year and carrier participation in extended operations are fixed assignments in all runs.

2. Problem Size

Problem size in terms of the number of columns and non-zero elements sent to the solver is a function of the number of substitutions allowed, the number of assignments fixed, the total number of constraints, and the cost limits imposed in the problem generator.

TABLE 8.

CPSKED Results

	Run 1 CPSKED(NS)	Run 2 CPSKED(SU)	Run 3 CPSKED(S)	Run 4 CPSKED(CLF)
-Characteristics-				
Total Ships:	111	111	111	111
Operational Ships:	105	105	105	105
Total Events:	19	19	19	19
Allowed Subs:	no	yes	yes	yes
Cost Limits:	yes	no	yes	yes
-Objectives-				
cost:	395,200	427,000	446,700	1,472,500
-Penalties-				
Schedule Selection:	0	0	0	0
Event/Ship-type:	4,144,000	0	0	0
Weapon Capability:	10,000	7,000	9,000	11,000
Total:	4,549,200	434,000	455,700	1,483,500
-Problem Size-				
Rows:	228	228	228	228
Columns:	4,109	15,193	10,723	3,984
Non-Zeros:	19,019	84,247	55,404	19,092
-Run Times-				
-(in cpu seconds)-				
Generator:	2.3	8.3	6.2	2.4
Solver:	23.0	172.8	113.0	22.6
Reports:	0.6	0.7	0.7	0.7

Substitutions dramatically increase the problem size as indicated by a comparison of runs 1 and 3; however, the event/ship-type penalties observed in run 1 indicate that all requirements could not be satisfied without substitutions. Commitments must be met, and consequently, substitutions are necessary to avoid event/ship-type penalties.

Fixing schedule assignments that are known *a priori* will significantly decrease the problem size; however, fixing assignments can be expected to increase the costs and may increase the number of goal violation penalties. Compare runs 3 and 4.

The number of event/ship-type constraints will influence the number of columns generated because more events are added to the event list used to generate the columns. However, the addition of weapon capability constraints only increases the number of rows in the problem.

The inclusion of cost limits in the problem generator results in a problem size reduction of approximately 30% with little degradation in the cost objective, compare runs 2 and 3.

3. Execution Times

Total execution time for model runs consists of generation time, solution time, and reporting time. To effectively employ CPSKED as a decision support system requires rapid execution. Generation and reporting time are relatively insignificant when compared to solution time. Solution time is influenced by the problem size, problem penalties, and the techniques employed by the solver. The solution times observed in this study compare very favorably with solution times for other large-scale set covering problems. [Refs. 3,4, and 11]

VI. CONCLUSIONS AND RECOMMENDATIONS

This study has demonstrated that optimization techniques can produce high quality annual fleet employment schedules efficiently. Response times are short enough to permit using this model in an interactive schedule planning system. Refinements in the implementation of this model can further reduce solution times.

The CINCLANTFLT versus CPSKED schedule comparisons indicate there is room for improving fleet employment schedules. Optimization models similar to CPSKED can become powerful management tools for developing, refining, and maintaining employment schedules.

An optimization model provides a means for considering "all" alternatives to determine the "best" schedule subject to the constraints supplied to the model. This schedule may then be used as a reference for comparing alternate schedules that may include additional criteria not evident in the initial model run. Because of the relatively fast response times, this process may be conducted iteratively until a final acceptable annual schedule is developed. The optimization model ensures that costs are minimized. The scheduler, or decision maker, must decide whether the additional criteria are justifiable in terms of the resulting increased costs. Thus, the model provides the decision maker with the capability of producing high quality optimum schedules that satisfy, or at least consider. all scheduling criteria.

In its present state of development, the CPSKED implementation is not an end-user product. It does not possess a user-friendly front end and has not been

fully integrated with the solver. Input data requirements are extensive and presently require fixed formatted files. An end-user implementation should include an interactive front end for generating event requirement input. The front-end should incorporate "canned" requirements that can be edited for recurring events. The model should also have access to a data base for extracting and updating the ship input data. Integration of the problem generator and the solver can reduce file handling and exploit more of the X System's capabilities to reduce overall execution time.

The model development in this study has focused on scheduling combatants to primary events. The model may be applied to other primary event scheduling problems, e.g., amphibious forces, service forces, etc., by changing the input data files and scheduling parameters.

Navy doctrine states that "The optimized peacetime employment schedule that has as its objective maximizing combat readiness should always be the goal and guide." CPSKED, or a similar optimizing decision support system, can, and should, be used to assist schedulers in achieving that objective.

APPENDIX A

SAMPLE EVENT INPUT DATA

Card Type	Card Columns	Data Description
All	1	Card type M = Major event card S = Sub-event card H = Hull requirement card T = Ship-type requirement card W = Weapon system requirement card N = Hull specification card
M	2-4	Event number
	5-26	Event name
	27-30	Julian start date
	31-34	Julian completion date
S	2	Event code E = Major employment C = Concurrent employment
	3	Status code S = Home fleet at-sea operations D = Deployed operations
	4-12	Employment term (EMPTERM)
	13-28	Location term
	29-43	Supplemental information
	44-63	Remarks
	64-67	Julian start date
	68-71	Julian completion date
H	2-14	Six 2 digit codes indicating the number of ships of types 1 thru 6 required by hull number. For each non-zero field an N card is required.
T	2-13	Six 2 digit codes indicating the number of ships of types 1 thru 6 required by ship-type. Does not include ships required on H card.
W	2-19	Up to nine 2 digit codes indicating the number of weapon systems of types 1 thru 9 required.
N	2-3	2 digit code indicating ship type
	4-39	Up to nine 4 digit ship hull numbers, the number of fields used must correspond with the number indicated on the H card for the corresponding ship type.

ship types	1 = CV/CVN 2 = CG/CGN 3 = DDG 4 = DD 5 = FFG 6 = FF
weapon systems	1 = AAW missile systems SM1-ER 2 = AAW missile systems SM1-MR 3 = AAW Radar system SPS-48 4 = Data link system NTDS Link-11 5 = Passive sonar system TASS/TACTAS 6 = Helo capability LAMPS 7 = 5"/54 Gun system

```
FILE: EVENTLG  DATA      A1

  EVENTLG (CPSKED)
M001MED 1-83                30013171
SE OPCON                      CINCUSNAVEUR                    30013130
SCDDEPLOY                                     MED 1-83        30013140
SE ENR      CONUS                                             31313140
SE LVUPK                                                      31413170
H01C202010205
T00C00000000
W02C40304030304
N01C067
N02C0410040
N03CC100037
N040544
N05C0080016
N061C981C9310431056 1C90
M002IO 1-83                 30013183
SE OPCON                      CINCPACFLT                      30013143
SCDDEPLOY                                     IO 1-83         30013153
SE ENR      CONUS                                             31443153
SE LVUPK                                                      31543183
H01C1C1000001
T000C00000000
W01C200020202J0
N01CC66
N020C19
N030043
NC61C44
MC03MEF 1-83                30013105
SE OPCON                      COMIDEASTFOR                    30013064
SCDDEPLOY                                     MEF 1-83        30013075
SE ENR      CONUS                                             30653075
SE LVUPK                                                      30763105
HC0CCC1010000
TC0CC000000000
W000000010001J0
N030023
NC40578
M004MEF 2-83                30013213
SE POM                                                        30013030
SESENR      ROTA                                              30313040
SCDDEPLOY                                     MEF 2-83        30313254
SE OPCON                      COMIDEASTFOR                    30413245
SE ENR      CONUS                                             32463254
SE LVUPK                                                      32553284
HC0CC00C10100
TC000000000000
WC000000100010J0
N040963
NC5C007
M005SNFL 1-83               30013242
SE ENR                                                        30013010
SCDDEPLOY                                     SNFL 1-83       30013211
SE OPCON                      STANAVFORLANT                   30103201
SE ENR      CONUS                                             32023211
SE LVUPK                                                      32123242
HC000000100000
TC0CC00C000000
NC4C974
M006IO 2-83                 30313285
SE POM                                                        30313061
SE ENR      ROTA                                              30623071
SCDDEPLOY                                     IO 2-83         30623255
SE OPCON                      CINCPACFLT                      30713246
SE ENR      CONUS                                             32463255
SE LVUPK                                                      32563285
HC1C100C000000
TC0CC01000001
W01C200020202J0
XC0CCC0690000
NC1C070
NC20C39
M007MED 2-83                30693355
```

```
FILE: EVENTLG  DATA      A1

SESREADEX  CARIBBEAN SEA  01-83                                  30693092
SE POM                                                           30933122
SE ENR     ROTA                                                  31233133
SCDDEPLOY                                    MED 2-83            31233325
SE OPCON                  CINCUSNAVEUR                           31333315
SE ENR     CONUS                                                 33163325
SE LVUPK                                                         33263355
H010C000000000
TC0C202C20303
WC2C40304030304
X000027383557
N010069
MC08COMPTUEX 2-83         30953112
SESCOMPTUEX                 02-83                                30953112
H000000000000
TC0C202020303
M009MEF 3-83              31073303
SE POM                                                           31073136
SE ENR     ROTA                                                  31373146
SCDDEPLOY                                    MEF 3-83            31373273
SE OPCON                  COMIDEASTFOR                           31473163
SE ENR     CONUS                                                 32643273
SE LVUPK                                                         32743303
HC0CC000000000
TC0C0000100011
W00C000010001J0
X000048006800
M010SOLID SHIELD 83       31193131
SESEXER    ATLANTIC OCEAN                SOLID SHIELD 83        31193131
HC00C000000000
T01C2020202020
X000027383648
X00C0000006859
M011SNFL 2-83             31403365
SE POM                                                           31403170
SE ENR                                                           31713180
SCDDEPLOY                                    SNFL 2-83           31713365
SE OPCON                  STANAVFORLANT                          31613355
SE ENR     CONUS                                                 33553365
HC0CC0CC000000
T00CC01C000000
XC000003937J8
M012OCEAN SAFARI 83       31483198
SESEXER    ATLANTIC OCEAN                UNITED EFFORT          31483157
SESEXER    NORTH ATLANTIC                OCEAN SAFARI 83        31583168
SESEXER    NORTH ATLANTIC                BALTOPS 83             31803188
SESENR     CONUS                                                 31893198
H010000000000
TC0C201C202000
X000027383647
N010067
M013COMPTUEX 3-83         31523168
SESCOMPTUEX                 03-83                                31523168
HC0CC000000000
TC0C202C20303
M014UNITAS                31523365
SE POM                                                           31213151
SE OPCON                    COMSOLANT                            31523344
SCDDEPLOY                                    UNITAS - WATC       31523344
SE LVUPK                                                         33453365
HC0CC00C000000
T00C001010001
X000C49396948
M015MEF 4-83              31663365
SE POM                                                           31663195
SE ENR     ROTA                                                  31963205
SCDDEPLOY                                    MEF 4-83            31963355
SE OPCON                  COMIDEASTFOR                           32063345
SE ENR     CONUS                                                 33463355
SE LVUPK                                                         33563365
HC0CC000000000
TC00000010001
```

```
FILE: EVENTLG  DATA      A1

W00000010001)0
X00CC48C06800
M016COMPTUEX 4-83        32213238
SESCOMPTUEX                04-83                                  32213238
HCOC000C00000
T00C202020303
M017IO 1-84              32413365
SE POM                                                          32413270
SE ENR      ROTA                                                32713281
SCDDEPLOY                                    IO 1-84            32713365
SE OPCON                   CINCPACFLT                           32823365
H000C00000000
TC00101000001
WC1C200C2020200
X00C000376900
M018MED 1-84             32443365
SESREADEX                  02-83                                32443263
SE POM                                                          32643293
SE ENR      ROTA                                                32943303
SCDDEPLOY                                    MED 1-84           32943365
SE OPCON                   CINCUSNAVEUR                         33043365
HC1000000000
TCOC202C20303
W02C4030403030)4
X00C027383547
X000C000069 00
N010C62
MC19COMPTUEX 1-84        33343349
SESCOMPTUEX                01-84                                33343349
HCOCC00C00000
T00C202020303
```

APPENDIX B

SAMPLE SHIP INPUT DATA

Card Column	Data Description
1-2	Ship-type code (1 thru 6)
3-6	Ship-type designation (CV/CVN, CG/CGN, DDG, DD, FFG, FF)
7-10	Ship hull number
11-33	Ship name
34-37	Overhaul or precom start date (current planning period)
38-41	Overhaul or precom completion date
42-45	Non operational start date (except overhaul)
45-48	Non operational completion period
49-52	Total days since last overhaul or commissioning thru the start of the current planning period.
53-56	Total deployed days since last overhaul thru the start of the current planning period.
57-60	Total home fleet operational days since last overhaul thru start of current planning period.
61-64	Total home fleet at-sea days since last overhaul thru start of current planning period.
65-68	Date last deployment completed or last day before planning period is ship is deployed or overhaul completion date or commissioning date.
69-78	weapon system indicators 1=installed, 0=not installed.
ship types	1 = CV/CVN 2 = CG/CGN 3 = DDG 4 = DD 5 = FFG 6 = FF
weapon systems	1 = AAW missile systems SM1-ER 2 = AAW missile systems SM1-MR 3 = AAW Radar system SPS-48 4 = Data link system NTDS Link-11 5 = Passive sonar system TASS/TACTAS 6 = Helo capability LAMPS 7 = 5"/54 Gun system

FILE: SHIP DATA A1

LANTFLT COMBATANTS

```
01CV   0043N00000CORAL SEA          3001336500000000000000000000000033650000000
01CV   0059N03359FORRESTAL          3001336500000000000000000000000033650000000
01CV   0060N03360SARATOGA           3001303030543114000000000000000030300000000
01CV   0062N03362INDEPENDENCE       0000000030323201109504400655019623460CCCCCC0
01CV   0066N03366AMERICA            0000000031893331062002980322009833650000000
01CV   0067N03367KENNEDY            0000CC0030013069100004780522015221930000000
01CVN  0068N03368NIMITZ             3168336500000000010950366072902182043CCCCCC0
01CVN  0069N03369EISENHOWER         0000000000000000010950383071202302193000000C
01CVN  0070N20993VINSON C           0000000032553365004200000042000023220000000
02CG   0017N52688YARNELL HE         0000000000000000940033606400181221610111001
02CG   0019N52690DALE               0000000000000000145005000950028236510111001
02CG   0020N52691TURNER RK          3001301500000000000000000000000030151011001
02CG   0026N52701BELKNAP            0000000000000000585014204430099210110111001
02CG   0027N52702DANIELS J          3001327500000000000000000000000032751011001
02CG   0028N52703WAINWRIGHT         0000000000000000000000000000000033651011001
02CG   0034N52709BIDDLE             0000000000000000685031703670105234710111001
02CGN  0036N20541CALIFORNIA         3001313800000000000000000000000031380111011
02CGN  0037N20669SOUTH CAROLINA     3001336500000000000000000000000033650111011
02CGN  0038N20681VIRGINIA           0000000000000000109503370758023021930111011
02CGN  0039N20682TEXAS              3256336500000000C0109503860709021420430111011
02CGN  0040N20624MISSISSIPPI        3213336500000000096503010664020023650111011
02CGN  0041N20807ARKANSAS           3274336500000000019000500140004123650111011
02CG   0047N00000TICONDEROGA       3001303100000000000000000000000030311011011
03DDG  0002N04668ADAMS CF           3032336500000000000000000000000033650100001
03DDG  0003N04669KING J             3001308700000000000000000000000030870100001
03DDG  0004N04670CLAWRENCE          0000000000000000001580000015800642207010000l
03DDG  0005N04671RICKETTS CV        0000C0000000000000900000009000302275010000l
03DDG  0006N04672BARNEY             3072336500000000C0103003920638019221940100001
03DDG  0010N04676SAMPSON            0000000000000000001870050013700422365010000l
03DDG  0011N04677SELLERS            3001322600000000000000000000000032260100001
03DDG  0017N04683CONYNGHAM          0000000000000000066001690509014820490100001
03DDG  0018N04684SEMMES             3001303700000000000000000000000030370100001
03DDG  0019N04685TATTNALL           0000000000000000030000000500010233501000001
03DDG  0023N04690BYRD RE            0000000000000000027700500227006823650100001
03DDG  0037N52231FARRAGUT           3278336500000000990034306470211236510010001
03DDG  0038N52232LUCE               3001307800000000000000000000000030781001001
03DDG  0039N52233MCDONOUGH          0000000000000000086503170548016523511001001
03DDG  0040N52234CONTZ              3001319000000000000000000000000031901001001
03DDG  0041N52235KING               3001315000000000000000000000000031501001001
03DDG  0042N52236MAHAN              0000000000000000052500000525020012021001001
03DDG  0043N52683DAHLGREN           0000000000000000109503950700021023651001001
03DDG  0044N52684PRATT WV           0000000003000000091503650550016523471001001
03DDG  0045N52685DEWEY              0000CC0C0000000C0055501530402012121811001001
03DDG  0046N52686PREBLE             3001306700000000000000000000000030671001001
03DDG  0993N21436KIDD               0000000000000000015500000155004222060101011
03DDG  0995N21438SCOTT              3001303000000000000000000000000030300101011
04DD   0944N52203MULLINNIX          3142336500000000034300000343013520220000001
04DD   0963N20574SPRUANCE           3244336500000000048501950290008821950C01111
04DD   0968N20588RADFORD AW         0000000000000000018900000189007521760001111
04DD   0969N20589PETERSON           3001310500000000000000000000000031050001111
04DD   0970N20590CARON              3001303800000000000000000000000030380001111
04DD   0974N20600COMTE DE GRASSE    3288336500000000109504190675021321010001111
04DD   0977N20603BRISCOE            3001319100000000000000000000000031910001111
04DD   0978N20604STUMP              3192336500000000109503900705021223650001111
04DD   0979N20611CONOLLY            0000000000000000106003240736022520490001111
04DD   0980N20612MOOSBRUGGER        3001312100000000000000000000000031210001111
04DD   0981N20613HANCOCK J          3001328000000C0C0000000000000000032800001111
04DD   0982N20614NICHOLSON          3001309000000000000000000000000030900001111
04DD   0983N20615RODGERS J          3001313500000000000000000000000031350001111
04DD   0987N20834DBANNON            3001307400000000000000000000000030740001111
04DD   0988N20835THORN              3001313000000000000000000000000031300001111
04DD   0997N00000HAYLER            3001328100000CCC0000000C0000000032810001111
04DD   0989N20836DEYO               0000000000000000006500137051301552311C001111
05FFG  0004N04595TALBOT             3001316500000000000000000000000031650100010
05FFG  0005N04598PAGE RL            3001336500000000000000000000000033650100010
05FFG  0006N04599FURER JA           0000C0000000000004680180028800852348C1CC010
05FFG  0007N21028PERRY DH           0000000000000000073002950435012523550100010
05FFG  0008N21032MCINERNEY          0000C0000000000002650050021500662365C1CC010
05FFG  0011N20964CLARK              0000000000000000036501530212006421800100010
05FFG  0013N20966MORRISON SE        0000CC0000000000365015002120071230801000l0
05FFG  0015N20968ESTOCIN            0000CC0000000000310018001300028234801CC010
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FILE: SHIP DATA A1

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05FFG 0016N20969SPRAGUE C       00000000000000000022500500175005123650100010
05FFG 0020N20973ANTRIM          00000C000000000000500000005000202315010001O
05FFG 0021N20974FLATLEY         00000C000000000000500000005000202315C1CC010
05FFG 0022N20975FARICN          30013069000000000000000000000000030690100010
05FFG 0024N20977WILLIAMS J      00000000000000000005000000050002023150100010
05FFG 0026N20979GALLERY         00000000000000000002000000020001023450lCC010
05FFG 0028N21053BOONE           30013196000000C000000000000000000031960100010
05FFG 0029N21054GROVES SW       30013242000000000000000000000000032420100010
05FFG 0031N21056STARK           30013365000000000000000000000000033650100010
05FFG 0032N21057HALL JL         30013227000000000000000000000000032270100010
05FFG 0034N21059FITCH A         30013324000000000000000000000000033240100010
06FF  1038N54036MCCLCY          00000000000000000090003430547017222340000111
06FF  1040N54037GARCIA          00000C000000000000550000005500202310000001l1
06FF  1043N54039MCDONNELL E     00000000000000000019200500142004523650000111
06FF  1044N54C4CBFJMBY          00000000000000000350000003500145201500001l1
06FF  1047N54042VOGE            30013255000000000000000000C000000003255000111
06FF  1049N54044KOELSCH         30013262000000000000000000000000003262000011
06FF  1056N54051CONNCLE         0000C000000000000109503090786024223110000111
06FF  1059N54054SIMS WS         00000000000000000093502620673020023130000111
06FF  1061N54056PATTERSCN       30013135000000000000000000000000003135000C111
06FF  1068N54063VREELAND        00000000000000000037500000375008013450000111
06FF  1072N54067BLAKELY         31663365000000000898034005580152234500CC1111
06FF  1075N54070TRIPPE          00000C000000000000605016904360132204900001l1
06FF  1078N20049HEWES J         00000C000000000000268000002680096209700OC111
06FF  1079N20050BOWEN           00000000000000000048501530332008521800000111
06FF  1080N20051PAUL            30013C200000000000000000000000000302000001l1
06FF  1081N20052AYLWIN          00000000000000000050001800320009523450OCC111
06FF  1082N20053MONTGOMERY E    30013249000000000000000000000000032490OC0111
06FF  1084N20055MCCANDLESS      30013365000000000000000000000000033650000111
06FF  1085N20056BEARY CB        00000000000000000010950329076602802049000C0111
06FF  1089N20067BROWN JL        00000C000000000000109502780817026922180000111
06FF  1090N20068AINSWORTH       32783365000000001095029707980220125600CCC1111
06FF  1091N20069MILLER          00000000000000000010950295080002401196000001l1
06FF  1092N20070HART TC         0000CC000000000C010950294080102512218000011l1
06FF  1093N20071CAPOCANNO       32273365000000000109503350760022413450OCC111
06FF  1094N20072PHARRIS         0000C000000000000109503500725026011960000011l1
06FF  1095N20073TRUETT          00000000000000000101704530564017523450000011l1
06FF  1096N20074VALDEZ          00000C000000000000109503340761021521000000111
06FF  1097N20075MOINESTER       00000C000000000006677016905080148204900001l1
06FF  1098N17700GLOVER          00000000000000000054001800360010823450OCC111
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APPENDIX C

SAMPLE SHIP STATISTICS REPORT

Column Heading	Data Description
Nr.	CPSKED ship number
Hull Nr.	Ship type and hull number
Ship Name	Ship name
Sked Cost	Schedule column cost, C_j
Ship Cost	Ship schedule cost, $C_{1j}+C_{2j}+C_{3j}$ note, this does not include substitution factor.
C1	Time between deployment cost, C_{1j}
C2	Deployment cost, C_{2j}
C3	Home fleet sea cost, C_{3j}
CY Days	Days since last overhaul or commissioning
DEP Days	Deployed days since last overhaul or commissioning
PCT Dep	Percentage of days deployed since last overhaul or commissioning
HOME Days	Home fleet days since last overhaul or commissioning
SEA Days	Home fleet sea days since last overhaul or commissioning
PCT Sea	Percentage of home fleet days spent at sea since last overhaul or commissioning
TBLD	Time between last deployments
Last DEP	Last deployment completion date or last day of planning period if deployed or in overhaul or commissioning or overhaul completion date
	Summary lines include fleet averages and standard deviations. Non-zeros indicate the number of ships used to compute the fleet summary statistics.

SHIP STATISTICS REPORT

EVENT FILE: EVENTLG (CPSKED) SHIP FILE: LANTFLT COMBATANTS

NR.	HULL NR.		SHIP NAME	SKED COST	SHIP COST	C1	C2	C3	CY DAYS	DEP DAYS	PCT DEP	HOME DAYS	SEA DAYS	PCT SEA	TBLD	LAST DEP
1	CV	43	CORAL SEA	0.0	0.0	0.0	0.0	0.0	0	0	0.00	0	0	0.00	0	3365
2	CV	59	FORRESTAL	0.0	0.0	0.0	0.0	0.0	0	0	0.00	0	0	0.00	0	3365
3	CV	60	SARATOGA	14.3	14.3	0.0	9.2	5.1	275	0	0.00	275	66	0.24	0	3030
4	CV	62	INDEPENDENCE	132.5	132.5	47.0	81.4	4.1	1290	511	0.40	779	239	0.31	313	3365
5	CV	66	AMERICA	173.5	173.5	0.0	169.6	3.9	842	450	0.53	392	111	0.28	0	3153
6	CV	67	KENNEDY	186.9	186.9	0.0	185.4	1.4	1296	617	0.48	679	219	0.32	0	3140
7	CVN	68	NIMITZ	12.5	12.5	0.0	5.4	7.1	1262	366	0.29	896	263	0.29	0	2043
8	CVN	69	EISENHOWER	165.4	165.4	65.0	99.2	1.2	1459	585	0.40	874	285	0.33	295	3325
9	CVN	70	VINSON C	225.9	226.4	127.5	94.4	4.5	296	193	0.65	103	12	0.12	105	3255
10	CG	17	YARNELL HE	7.8	7.8	6.0	0.4	1.4	1304	430	0.33	910	296	0.33	420	3365
11	CG	19	DALE	32.5	32.5	0.0	32.5	0.0	509	202	0.40	307	102	0.33	0	3153
12	CG	20	TURNER RK	44.9	45.4	40.5	4.6	0.4	350	71	0.20	279	91	0.33	279	3365
13	CG	26	BELKNAP	39.5	40.2	2.7	28.0	9.5	949	344	0.36	605	154	0.25	387	3325
14	CG	27	DANIELS J	5.6	5.6	0.0	3.0	2.6	90	0	0.00	90	17	0.19	0	3275
15	CG	28	WAINWRIGHT	13.2	13.2	0.0	12.1	1.0	364	0	0.00	364	116	0.32	0	3365
16	CG	34	BIDDLE	87.0	87.0	48.0	38.7	0.4	1049	388	0.37	660	218	0.33	312	3365
17	CGN	36	CALIFORNIA	8.0	8.0	0.0	7.6	0.4	227	0	0.00	227	76	0.33	0	3138
18	CGN	37	SOUTH CAROLINA	0.0	0.0	0.0	0.0	0.0	0	0	0.00	0	0	0.00	0	3365
19	CGN	38	VIRGINIA	122.4	122.4	65.0	53.2	4.3	1459	539	0.37	920	285	0.31	295	3325
20	CGN	39	TEXAS	137.6	138.0	2.4	129.4	6.1	1350	579	0.43	771	226	0.29	384	3255
21	CGN	40	MISSISSIPPI	54.3	54.3	0.0	48.1	6.3	1177	440	0.37	737	214	0.29	0	3140
22	CGN	41	ARKANSAS	36.3	36.3	0.0	34.8	1.4	463	189	0.41	274	84	0.31	0	3140
23	CG	47	TICONDEROGA	52.1	52.6	48.5	4.0	0.1	334	71	0.21	263	87	0.33	263	3365
24	DDG	2	ADAMS CF	1.9	1.9	0.0	1.0	0.9	31	0	0.00	31	6	0.19	0	3365
25	DDG	3	KING J	13.6	13.6	0.0	9.3	4.3	278	0	0.00	278	71	0.26	0	3087
26	DDG	4	LAWRENCE	79.6	80.1	39.5	28.2	12.4	522	202	0.39	320	119	0.37	281	3325
27	DDG	5	RICKETTS CV	101.1	101.1	59.0	40.8	1.2	454	192	0.42	262	81	0.31	242	3344
28	DDG	6	BARNEY	31.4	31.4	0.0	25.4	6.0	1101	392	0.36	709	206	0.29	0	2194
29	DDG	10	SAMPSON	12.4	12.4	0.0	5.5	6.9	551	189	0.34	362	86	0.24	0	3140
30	DDG	11	SELLERS	8.5	8.5	0.0	4.6	3.9	139	0	0.00	139	27	0.19	0	3226
31	DDG	17	CONYNGHAM	27.9	28.7	1.8	21.0	5.9	1024	362	0.35	680	197	0.29	378	3255
32	DDG	18	SEMMES	55.2	55.7	51.5	3.8	0.4	328	71	0.22	257	86	0.33	257	3365
33	DDG	19	TATTNALL	142.0	142.5	79.5	62.8	0.3	394	194	0.49	220	72	0.33	201	3365
34	DDG	23	BYRD RE	13.6	11.2	0.0	8.9	2.2	641	124	0.19	517	161	0.31	0	3075
35	DDG	37	FARRAGUT	61.4	61.4	0.0	60.1	1.3	1267	482	0.38	785	255	0.32	0	3140
36	DDG	38	LUCE	11.7	11.7	0.0	9.6	2.1	287	0	0.00	287	85	0.30	0	3078
37	DDG	39	MCDONOUGH	54.5	54.5	52.0	2.1	0.4	1229	388	0.32	841	278	0.33	308	3365
38	DDG	40	SCONTZ	10.7	10.7	0.0	5.8	4.9	175	0	0.00	175	34	0.19	0	3190
39	DDG	41	KING	13.1	13.1	0.0	7.2	5.9	215	0	0.00	215	42	0.20	0	3150
40	DDG	42	MAHAN	35.5	35.5	23.0	10.3	2.2	889	193	0.22	696	234	0.34	590	3255
41	DDG	43	DAHLGREN	65.1	65.1	0.0	61.2	3.9	1459	547	0.37	912	284	0.31	0	3153
42	DDG	44	PRATT WV	8.4	6.6	0.0	6.1	0.5	1279	365	0.29	914	302	0.33	0	2347
43	DDG	45	DEWEY	52.3	46.5	39.0	1.7	5.8	919	289	0.31	630	181	0.29	321	3273
44	DDG	46	PREBLE	10.8	10.8	0.0	9.9	0.8	298	0	0.00	298	95	0.32	0	3067
45	DDG	993	KIDD	69.9	69.9	39.0	29.2	1.7	519	202	0.39	317	97	0.31	282	3325
46	DDG	995	SCOTT	61.4	61.9	59.5	1.8	0.7	335	94	0.28	241	77	0.32	241	3365
47	DD	944	MULLINNIX	22.3	22.3	0.0	2.2	20.1	484	139	0.29	345	135	0.39	0	3140
48	DD	963	SPRUANCE	176.2	176.2	0.0	175.6	0.6	728	418	0.57	310	100	0.32	0	3254
49	DD	968	RADFORD AW	55.0	55.0	24.0	17.9	13.1	553	202	0.37	351	130	0.37	312	3325
50	DD	969	PETERSON	9.1	9.1	0.0	8.7	0.4	260	0	0.00	260	87	0.33	0	3105

NR.	HULL NR.	SHIP NAME	SKED COST	SHIP COST	C1	C2	C3	CY DAYS	DEP DAYS	PCT DEP	HOME DAYS	SEA DAYS	PCT SEA	TMLD	LAST DEP
51	DD 970	CARON	74.3	65.5	63.5	1.5	0.5	327	94	0.29	233	75	0.32	233	3365
52	DD 974	COMTE DE GRASSE	173.3	173.3	0.0	160.8	4.5	1382	629	0.46	752	228	0.30	0	3211
53	DD 977	DRISCOE	7.6	7.6	0.0	5.8	1.8	174	0	0.00	174	49	0.28	0	3191
54	DD 978	STOUT	37.9	37.9	0.0	35.8	2.1	1286	464	0.36	822	263	0.32	0	3075
55	DD 979	CONOLLY	62.6	63.5	7.9	51.8	3.8	1424	526	0.37	898	280	0.31	439	3325
56	DD 980	COSBROGGER	8.2	8.2	0.0	8.1	0.1	244	0	0.00	244	81	0.33	0	3121
57	DD 981	HANCOCK J	5.3	5.3	0.0	2.8	2.5	85	0	0.00	85	16	0.19	0	3280
58	DD 982	NICHOLSON	9.9	9.9	0.0	9.2	0.7	275	0	0.00	275	88	0.32	0	3090
59	DD 983	ROGERS J	7.8	7.8	0.0	7.7	0.1	230	0	0.00	230	76	0.33	0	3135
60	DD 987	SHANNON	10.3	10.3	0.0	9.7	0.6	291	0	0.00	291	94	0.32	0	3074
61	DD 988	THORN	7.9	7.9	0.0	7.8	0.1	235	0	0.00	235	78	0.33	0	3130
62	DD 997	TAYLOR	5.2	5.2	0.3	2.8	2.4	84	0	0.00	84	16	0.19	0	3281
63	DD 989	DEYO	117.2	117.2	110.0	4.2	3.0	1014	296	0.29	718	224	0.31	250	3355
64	FFG 4	TALBOT	8.8	8.8	0.0	6.7	2.1	200	0	0.00	200	56	0.28	0	3365
65	FFG 5	PAGE RL	0.0	0.0	0.0	0.0	0.0	0	0	0.00	0	0	0.00	0	3365
66	FFG 6	KIRKER JA	11.1	11.1	0.0	9.7	1.4	832	180	0.22	652	210	0.32	0	3348
67	FFG 7	PERRY OH	159.7	159.7	0.0	153.7	6.0	1094	518	0.47	576	162	0.28	0	3254
68	FFG 8	CINCINNATI	2.9	2.9	0.0	2.0	0.9	629	189	0.30	440	142	0.32	0	3140
69	FFG 11	CLARK	15.6	15.3	9.6	4.2	1.5	729	247	0.34	482	153	0.32	456	3365
70	FFG 13	CPISON SE	12.7	12.0	9.0	2.2	0.8	729	221	0.30	505	164	0.32	351	3365
71	FFG 15	STOCIN	4.9	4.9	0.0	4.4	0.5	674	180	0.27	494	165	0.33	0	3348
72	FFG 16	SPRAGUE C	2.0	2.0	0.0	0.7	1.2	589	189	0.32	400	127	0.32	0	3140
73	FFG 20	ANTRIM	15.5	14.7	8.0	6.7	0.0	414	71	0.17	343	114	0.33	344	3365
74	FFG 21	FLATLEY	14.7	14.7	8.0	6.7	0.0	414	71	0.17	343	114	0.33	344	3365
75	FFG 22	HARLON	10.6	10.6	0.0	9.9	0.7	296	0	0.00	296	95	0.32	0	3069
76	FFG 24	WILLIAMS J	14.9	14.9	8.0	6.7	0.2	414	71	0.17	343	113	0.33	344	3365
77	FFG 26	GALLERY	28.7	28.7	23.0	5.7	0.0	384	71	0.18	313	104	0.33	314	3365
78	FFG 28	DONE	6.9	6.9	0.0	5.6	1.3	169	0	0.00	169	50	0.30	0	3196
79	FFG 29	GROVES SW	4.5	4.5	0.0	4.1	0.4	123	0	0.00	123	39	0.32	0	3242
80	FFG 31	STARK	0.0	0.0	0.0	0.0	0.0	0	0	0.00	0	0	0.00	0	3365
81	FFG 32	HALL JL	5.4	5.4	0.0	4.6	0.8	138	0	0.00	138	42	0.30	0	3227
82	FFG 34	FITCH A	2.5	2.5	0.0	1.4	1.1	41	0	0.00	41	8	0.20	0	3324
83	CG 1038	CCLOY	8.5	7.7	6.5	0.7	0.5	1264	414	0.33	840	277	0.33	425	3365
84	FF 1040	SACIA	75.4	75.9	54.5	19.5	1.9	419	159	0.38	260	77	0.30	251	3355
85	FF 1043	COONNELL E	4.1	4.1	0.0	3.9	0.2	556	189	0.34	367	121	0.33	0	3140
86	FF 1044	RUMBY	8.6	8.6	0.0	8.6	0.0	714	152	0.21	562	187	0.33	0	3153
87	FF 1047	VOGE	6.8	6.8	0.0	3.7	3.1	110	0	0.00	110	21	0.19	0	3255
88	FF 1049	CELSCH	6.3	6.3	0.0	3.4	2.9	103	0	0.00	103	20	0.19	0	3262
89	FF 1056	CENNON E	7.5	7.5	0.0	3.8	3.7	1455	448	0.31	1011	318	0.31	0	3143
90	FF 1059	SIMS WS	26.9	24.3	14.0	10.0	0.1	1299	333	0.26	966	322	0.33	346	3365
91	FF 1061	PATTERSON	7.8	7.8	0.0	7.7	0.1	230	0	0.00	230	76	0.33	0	3135
92	FF 1068	FREELAND	30.8	28.0	14.8	4.4	8.8	739	202	0.27	537	135	0.25	508	3325
93	FF 1072	BARKLEY	7.3	6.9	0.0	1.4	5.6	1063	340	0.32	723	213	0.29	0	2349
94	FF 1075	TRIPPE	57.7	58.6	7.9	48.3	2.4	969	371	0.38	598	187	0.31	439	3325
95	FF 1078	EWES J	16.7	11.8	3.1	0.8	7.8	632	202	0.32	430	151	0.35	391	3325
96	FF 1079	OWEN	52.6	52.6	38.0	6.3	8.3	849	289	0.34	560	145	0.26	322	3273
97	FF 1080	PAUL	56.2	56.7	54.5	2.1	0.1	345	94	0.27	251	83	0.33	251	3365
98	FF 1081	YEWIN	90.5	90.5	46.0	3.7	0.8	864	251	0.29	613	200	0.33	314	3365
99	FF 1082	OMTGOMERY E	7.0	7.0	0.0	1.9	3.1	116	0	0.00	116	23	0.20	0	3299
100	FF 1084	CLANOLESS	0.0	0.0	0.0	0.0	0.0	0	0	0.00	0	0	0.00	0	3365
101	FF 1085	BARY DR	39.1	39.9	1.8	36.2	2.0	1459	522	0.36	937	314	0.34	378	3255
102	FF 1089	BROWN JL	64.5	64.5	61.0	1.6	1.9	1459	470	0.32	989	320	0.32	299	3348
103	FF 1090	CRISWORTH	11.6	11.6	3.0	2.1	9.5	1272	436	0.32	836	264	0.28	0	3140
104	FF 1091	MILLER	45.2	45.9	29.7	11.2	5.1	1459	497	0.34	962	295	0.31	657	3325
105	FF 1092	LAPT TC	68.4	63.2	61.0	0.2	2.0	1459	486	0.33	971	314	0.32	299	3348
106	FF 1093	CAPODANNO	42.3	42.3	0.0	34.1	8.2	1321	474	0.36	847	241	0.28	0	3140

NR.	HULL NR.	SHIP NAME	SKED COST	SHIP COST	C1	C2	C3	CY DAYS	DEP DAYS	PCT DEP	HOME DAYS	SEA DAYS	PCT SEA	TBLD	LAST DEP
107	FF 1094	PHARRIS	81.0	81.6	23.6	57.2	0.9	1459	543	0.37	896	294	0.33	596	3255
108	FF 1095	TRUETT	4.4	3.5	0.0	0.7	2.8	1381	453	0.33	928	295	0.32	0	2345
109	FF 1096	VALDEZ	59.6	60.4	2.8	50.2	7.5	1459	536	0.37	923	270	0.29	388	3325
110	FF 1097	MOINESTER	50.5	36.3	7.9	24.3	4.0	1041	371	0.36	670	203	0.30	439	3325
111	FF 1098	GLOVER	20.1	20.1	0.0	18.0	2.2	904	319	0.35	585	184	0.31	0	3140
		AVERAGES	43.15	42.68	34.66	24.57	2.93	705.98	314.51	0.34	481.70	149.19	0.30	344.43	
		STANDARD DEVIATIONS	48.91	49.00	28.92	40.11	3.28	468.49	162.06	0.09	285.21	259.14	0.05	103.21	
		NON ZEROS (N)	105.00	105.00	46.00	105.00	105.00	105.00	75.00	75.00	105.00	105.00	105.00	46.00	

APPENDIX D

SAMPLE EVENT REPORT

The Event Report lists all primary events that have been scheduled. The "Type Requirement" line indicates the constraint row numbers associated with the event/ship-type requirements in CPSKED and the number of units of each type required. The ships assigned by CPSKED are listed under "Forces Assigned."

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                        EVENT REPORT
EVENT FILE:  EVENTLG (CPSKED)        SHIP FILE:  LANTFLT COMBATANTS


MED 1-83                START DATE: 3001  STOP DATE: 3171

TYPE REQMTS( 112- 117): CV/CVN: 1  CG/CGN: 2  DDG: 2  DD: 1  FFG: 2  FF: 5

FORCES ASSIGED:
     67  KENNEDY
     40  MISSISSIPPI
     41  ARKANSAS
     10  SAMPSON
     37  FARRAGUT
    944  MULLINNIX
      8  MCINERNEY
     16  SPRAGLE C
   1043  MCDONNELL E
   1056  CONNOLF
   1090  AINSWORTH
   1093  CAPODANNO
   1098  GLOVER

IO 1-83                 START DATE: 3001  STOP DATE: 3183

TYPE REQMTS( 118- 121): CV/CVN: 1  CG/CGN: 1  DDG: 1  DD: 0  FFG: 0  FF: 1

FORCES ASSIGED:
     66  AMERICA
     19  DALE
     43  DAHLGREN
   1044  BRUMBY

MEF 1-83                START DATE: 3001  STOP DATE: 3105

TYPE REQMTS( 122- 123): CV/CVN: 0  CG/CGN: 0  DDG: 1  DD: 1  FFG: 0  FF: 0

FORCES ASSIGED:
     23  BYRD RE
    978  STUMP

MEF 2-83                START DATE: 3001  STOP DATE: 3213

TYPE REQMTS( 124- 125): CV/CVN: 0  CG/CGN: 0  DDG: 0  DD: 1  FFG: 1  FF: 0

FORCES ASSIGED:
    963  SPRUANCE
      7  PERRY OH

SNFL 1-83               START DATE: 3001  STOP DATE: 3242

TYPE REQMTS( 126- 126): CV/CVN: 0  CG/CGN: 0  DDG: 0  DD: 1  FFG: 0  FF: 0

FORCES ASSIGED:
    974  COMTE DE GRASSE

IO 2-83                 START DATE: 3031  STOP DATE: 3285

TYPE REQMTS( 127- 130): CV/CVN: 1  CG/CGN: 1  DDG: 1  DD: 0  FFG: 0  FF: 1

FORCES ASSIGED:
     70  VINSON C
```

```
     39  TEXAS
     17  CONYNGHAM
     42  MAHAN
   1085  BEARY DB
   1094  PHARRIS

MED 2-83              START DATE: 3069  STOP DATE: 3355

TYPE REQMTS( 131- 136): CV/CVN: 1  CG/CGN: 2  DDG: 2  DD: 2  FFG: 3  FF: 3

FORCES ASSIGED:
     69  EISENHOWER
     26  BELKNAP
     38  VIRGINIA
      4  LAWRENCE
    993  KIDD
    968  RADFORD AW
    979  CONOLLY
   1068  VREELAND
   1075  TRIPPE
   1078  HEWES J
   1091  MILLER
   1096  VALDEZ
   1097  MOINESTER

COMPTUEX 2-83         START DATE: 3095  STOP DATE: 3112

TYPE REQMTS( 137- 141): CV/CVN: 0  CG/CGN: 2  DDG: 2  DD: 2  FFG: 3  FF: 3

FORCES ASSIGED:
     17  YARNELL HE
     20  TURNER RK
     28  WAINWRIGHT
      5  RICKETTS CV
     19  TATTNALL
    995  SCOTT
    970  CARON
    982  NICHOLSON
    989  DEYO
      6  FURER JA
     15  ESTOCIN
     20  ANTRIM
     21  FLATLEY
     26  GALLERY
   1040  GARCIA
   1072  BLAKELY
   1080  PAUL
   1089  BROWN JL
   1092  HART TC

MEF 3-83              START DATE: 3107  STOP DATE: 3303

TYPE REQMTS( 142- 143): CV/CVN: 0  CG/CGN: 0  DDG: 0  DD: 1  FFG: 0  FF: 1

FORCES ASSIGED:
     45  DEWEY
   1079  BOWEN

SOLID SHIELD 83       START DATE: 3119  STOP DATE: 3131

TYPE REQMTS( 144- 149): CV/CVN: 1  CG/CGN: 2  DDG: 2  DD: 2  FFG: 2  FF: 2

FORCES ASSIGED:
     60  SARATOGA
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    68  NIMITZ
    17  YARNELL HE
    28  WAINWRIGHT
    19  TATTNALL
    38  LUCE
    44  PRATT WV
   995  SCOTT
   970  CARON
   978  STUMP
   989  DEYO
  1038  MCCLOY
  1059  SIMS WS
  1072  BLAKELY
  1081  AYLWIN
  1092  HART TC
  1095  TRUETT

SNFL 2-83              START DATE: 3140  STOP DATE: 3365

TYPE REQMTS( 150- 150): CV/CVN: 0   CG/CGN: 0   DDG: 1   DD: 0   FFG: 0   FF: 0

FORCES ASSIGED:
    19  TATTNALL

OCEAN SAFARI 83        START DATE: 3148  STOP DATE: 3198

TYPE REQMTS( 151- 155): CV/CVN: 1   CG/CGN: 2   DDG: 1   DD: 2   FFG: 2   FF: 0

FORCES ASSIGED:
    67  KENNEDY
    34  BIDDLE
    23  BYRD RE
    39  MCDONOUGH
    44  PRATT WV
    46  PREBLE
   969  PETERSON
   987  OBANYON
     6  FURER JA
    11  CLARK
    22  FARION
  1095  TRUETT

COMPTUEX 3-83          START DATE: 3152  STOP DATE: 3168

TYPE REQMTS( 156- 160): CV/CVN: 0   CG/CGN: 2   DDG: 2   DD: 2   FFG: 3   FF: 3

FORCES ASSIGED:
    17  YARNELL HE
    36  CALIFORNIA
    47  TICONDEROGA
     3  KING J
    18  SEMMES
    38  LUCE
   978  STUMP
   980  MOOSBRUGGER
   983  RODGERS J
    13  MORISON SE
    15  ESTOCIN
    24  WILLIAMS J
```

```
   1038  MCCLOY
   1059  SIMS WS
   1061  PATTERSON
   1080  PAUL
   1081  AYLWIN

UNITAS                  START DATE: 3152  STOP DATE: 3365

TYPE REQMTS( 161- 163): CV/CVN: 0  CG/CGN: 0  DDG: 1  DD: 1  FFG: 0  FF: 1

FORCES ASSIGED:
      5  RICKETTS CV
   1089  BROWN JL
   1092  HART TC

MEF 4-83                START DATE: 3166  STOP DATE: 3365

TYPE REQMTS( 164- 165): CV/CVN: 0  CG/CGN: 0  DDG: 0  DD: 1  FFG: 0  FF: 1

FORCES ASSIGED:
    989  DEYO
   1040  GARCIA

COMPTUEX 4-83           START DATE: 3221  STOP DATE: 3238

TYPE REQMTS( 166- 170): CV/CVN: 0  CG/CGN: 2  DDG: 2  DD: 2  FFG: 3  FF: 3

FORCES ASSIGED:
     17  YARNELL HE
     19  DALE
     41  ARKANSAS
     37  FARRAGUT
     43  DAHLGREN
     44  PRATT WV
    980  MOOSBRUGGER
    982  NICHOLSON
    988  THORN
      4  TALBOT
      8  MCINERNEY
     15  ESTOCIN
     16  SPRAGUE C
     28  BOONE
   1043  MCDONNELL F
   1056  CONNOLE
   1059  SIMS WS
   1090  AINSWORTH
   1098  GLOVER

IO 1-84                 START DATE: 3241  STOP DATE: 3365

TYPE REQMTS( 171- 173): CV/CVN: 0  CG/CGN: 1  DDG: 1  DD: 0  FFG: 0  FF: 1

FORCES ASSIGED:
     17  YARNELL HE
    995  SCOTT
    970  CAROL
     11  CLARK
   1080  PAUL

MED 1-84                START DATE: 3244  STOP DATE: 3365

TYPE REQMTS( 174- 179): CV/CVN: 1  CG/CGN: 2  DDG: 2  DD: 2  FFG: 3  FF: 3

FORCES ASSIGED:
     62  INDEPENDENCE
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```
      20  TURNER RK
      34  BIDDLE
      47  TICONDEROGA
      18  SEMMES
      39  MCDONOUGH
      13  MORISON SE
      20  ANTRIM
      21  FLATLEY
      24  WILLIAMS J
      26  GALLERY
    1038  MCCLOY
    1059  SIMS WS
    1081  AYLWIN

COMPTUEX 1-84          START DATE: 3334  STOP DATE: 3349

TYPE REQMTS( 180- 184): CV/CVN: 0  CG/CGN: 2  DDG: 2  DD: 2  FFG: 3  FF: 3

FORCES ASSIGED:
      19  DALE
      28  WAINWRIGHT
      36  CALIFORNIA
      17  CONYNGHAM
      43  DAHLGREN
      45  DEWEY
     977  BRISCOE
     983  RODGERS J
     988  THORN
       8  MCINERNEY
      15  ESTOCIN
      16  SPRAGUE C
      29  GROVES SW
      32  HALL JL
    1043  MCDONNELL E
    1056  CONNOLE
    1061  PATTERSON
    1079  BOWEN
    1098  GLOVER
```

APPENDIX E

SAMPLE SHIP SCHEDULE REPORT

The Ship Schedule Report is in a format similar to the CINCLANTFLT Quarterly Employment Schedule. All EMPTERMS associated with a primary event are listed.

SHIP SCHEDULE REPORT

EVENT FILE: EVENTLG (CPSKED) SHIP FILE: LANTFLT COMBATANTS

UNIT IDENTIFICATION				START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
CV	43	CORAL SEA	N00000					
CV	59	FORRESTAL	N03359					
CV	60	SARATOGA	N03360					
				3119	3131	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - SOLID SHIELD 83				
CV	62	INDEPENDENCE	N03362					
				3244	3263	E READEX		02-83
				3264	3293	E POM		
				3294	3303	E ENR	ROTA	
				3294	3365	C DEPLOY		
				* * R E M A R K - MED 1-84				
				3304	3365	E OPCON		CINCUSNAVEUR
CV	66	AMERICA	N03366					
				3001	3143	E OPCON		CINCPACFLT
				3001	3153	C DEPLOY		
				* * R E M A R K - ID 1-83				
				3144	3153	E ENR	CONUS	
				3154	3183	E LVUPK		
CV	67	KENNEDY	N03367					
				3001	3130	E OPCON		CINCUSNAVEUR
				3001	3140	C DEPLOY		
				* * R E M A R K - MED 1-83				
				3131	3140	E ENR	CONUS	
				3141	3170	E LVUPK		
				3148	3157	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - UNITED EFFORT				
				3158	3168	E EXER	NORTH ATLANTIC	
				* * R E M A R K - OCEAN SAFARI 83				
				3180	3188	E EXER	NORTH ATLANTIC	
				* * R E M A R K - BALTOPS 83				
				3189	3198	E ENR	CONUS	
CVN	68	NIMITZ	N03368					
				3119	3131	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - SOLID SHIELD 83				
CVN	69	EISENHOWER	N03369					
				3069	3092	E READEX	CARIBBEAN SEA	01-83
				3093	3122	E POM		
				3123	3133	E ENR	ROTA	
				3123	3325	C DEPLOY		
				* * R E M A R K - MED 2-83				
				3133	3315	E OPCON		CINCUSNAVEUR
				3316	3325	E ENR	CONUS	
				3326	3355	E LVUPK		
CVN	70	VINSON C	N20993					
				3031	3061	E POM		
				3062	3071	E ENR	ROTA	
				3062	3255	C DEPLOY		
				* * R E M A R K - ID 2-83				
				3071	3246	E OPCON		CINCPACFLT
				3246	3255	E ENR	CONUS	
				3256	3285	E LVUPK		
CG	17	YARNELL HE	N52688					

UNIT IDENTIFICATION				START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
				3095	3112	E	COMPTUEX	02-83
				3119	3131	E	EXER ATLANTIC OCEAN	
				* * R E M A R K - SCLIO SHIELO 83				
				3152	3168	E	COMPTUEX	03-83
				3221	3238	E	COMPTUEX	04-83
				3241	3270	E	POM	
				3271	3281	E	ENR ROTA	
				3271	3365	C	OEPLOY	
				* * R E M A R K - IO 1-84				
CG	19	OALE	N52690	3282	3365	E	OPCON	CINCPACFLT
				3001	3143	E	OPCON	CINCPACFLT
				3001	3153	C	OEPLOY	
				* * R E M A R K - IC 1-83				
				3144	3153	E	ENR CONUS	
				3154	3183	E	LVUPK	
				3221	3238	E	COMPTUEX	04-83
				3334	3349	E	COMPTUEX	01-84
CG	20	TURNER RK	N52691	3095	3112	E	COMPTUEX	02-83
				3244	3263	E	READEX	02-83
				3264	3293	E	POM	
				3294	3303	E	ENR ROTA	
				3294	3365	C	OEPLOY	
				* * R E M A R K - MEO 1-84				
CG	26	BELKNAP	N52701	3304	3365	E	OPCON	CINCUSNAVEUR
				3069	3092	E	READEX CARIBBEAN SEA	01-83
				3093	3122	E	POM	
				3123	3133	E	ENR ROTA	
				3123	3325	C	OEPLOY	
				* * R E M A R K - MEO 2-83				
				3133	3315	E	OPCON	CINCUSNAVEUR
				3316	3325	E	ENR CONUS	
				3326	3355	E	LVUPK	
CG	27	DANIELS J	N52702					
CG	28	WAINWRIGHT	N52703					
				3095	3112	E	COMPTUEX	02-83
				3119	3131	E	EXER ATLANTIC OCEAN	
				* * R E M A R K - SOLID SHIELO 83				
CG	34	BIDDLE	N52709	3334	3349	E	COMPTUEX	01-84
				3148	3157	E	EXER ATLANTIC OCEAN	
				* * R E M A R K - UNITED EFFORT				
				3158	3168	E	EXER NORTH ATLANTIC	
				* * R E M A R K - OCEAN SAFARI 83				
				3180	3188	E	EXER NORTH ATLANTIC	
				* * R E M A R K - BALTOPS 83				
				3189	3198	E	ENR CONUS	
				3244	3263	E	READEX	02-83
				3264	3293	E	POM	
				3294	3303	E	ENR ROTA	
				3294	3365	C	OEPLOY	
				* * R E M A R K - MED 1-84				
CGN	36	CALIFORNIA	N20541	3304	3365	E	OPCON	CINCUSNAVEUR

UNIT IDENTIFICATION				START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
				3152	3168	E COMPTUEX		03-83
				3334	3349	E COMPTUEX		01-84
CGN	37	SOUTH CAROLINA	N20669					
CGN	38	VIRGINIA	N20681					
				3069	3092	E READEX	CARIBBEAN SEA	01-83
				3093	3122	E POM		
				3123	3133	E ENR	ROTA	
				3123	3325	C DEPLOY		
				* * R E M A R K - MED 2-83				
				3133	3315	E OPCON		CINCUSNAVEUR
				3316	3325	E ENR	CONUS	
				3326	3355	E LVUPK		
CGN	39	TEXAS	N20682					
				3031	3061	E POM		
				3062	3071	E ENR	ROTA	
				3062	3255	C DEPLOY		
				* * R E M A R K - ID 2-83				
				3071	3246	E OPCON		CINCPACFLT
				3246	3255	E ENR	CONUS	
				3256	3285	E LVUPK		
CGN	40	MISSISSIPPI	N20624					
				3001	3130	E OPCON		CINCUSNAVEUR
				3001	3140	C DEPLOY		
				* * R E M A R K - MED 1-83				
				3131	3140	E ENR	CONUS	
				3141	3170	E LVUPK		
CGN	41	ARKANSAS	N20807					
				3001	3130	E OPCON		CINCUSNAVEUR
				3001	3140	C DEPLOY		
				* * R E M A R K - MED 1-83				
				3131	3140	E ENR	CONUS	
				3141	3170	E LVUPK		
				3221	3238	E COMPTUEX		04-83
CG	47	TICONDEROGA	N00000					
				3152	3168	E COMPTUEX		03-83
				3244	3263	E READEX		02-83
				3264	3293	E POM		
				3294	3303	E ENR	ROTA	
				3294	3365	C DEPLOY		
				* * R E M A R K - MED 1-84				
				3304	3365	E OPCON		CINCUSNAVEUR
DDG	2	ADAMS CF	N04668					
DDG	3	KING J	N04669					
				3152	3168	E COMPTUEX		03-83
DDG	4	LAWRENCE	N04670					
				3069	3092	E READEX	CARIBBEAN SEA	01-83
				3093	3122	E POM		
				3123	3133	E ENR	ROTA	
				3123	3325	C DEPLOY		
				* * R E M A R K - MED 2-83				
				3133	3315	E OPCON		CINCUSNAVEUR
				3316	3325	E ENR	CONUS	
				3326	3355	E LVUPK		
DDG	5	RICKETTS CV	N04671					
				3095	3112	E COMPTUEX		02-83
				3121	3151	E POM		

UNIT IDENTIFICATION				START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
				3152	3344	E OPCON		COMSOLANT
				3152	3344	C DEPLOY		
				* * R E M A R K - UNITAS - WATC				
				3345	3365	E LVUPK		
DDG	6	BARNEY	ND4672					
DDG	10	SAMPSON	ND4676					
				3001	3130	E OPCON		CINCUSNAVEUR
				3001	3140	C DEPLOY		
				* * R E M A R K - MED 1-83				
				3131	3140	E ENR	CONUS	
				3141	3170	E LVUPK		
DDG	11	SELLERS	N04677					
DDG	17	CONYNGHAM	N04683					
				3031	3061	E POM		
				3062	3071	E ENR	ROTA	
				3062	3255	C DEPLOY		
				* * R E M A R K - ID 2-83				
				3071	3246	E OPCON		CINCPACFLT
				3246	3255	E ENR	CONUS	
				3256	3285	E LVUPK		
				3334	3349	E COMPTUEX		01-84
DDG	18	SEMMES	N04684					
				3152	3168	E COMPTUEX		03-83
				3244	3263	E READEX		02-83
				3264	3293	E POM		
				3294	3303	E ENR	ROTA	
				3294	3365	C DEPLOY		
				* * P E M A R K - MED 1-84				
				3304	3365	E OPCON		CINCUSNAVEUR
DDG	19	TATTNALL	ND4685					
				3095	3112	E COMPTUEX		02-83
				3119	3131	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - SOLID SHIELD 83				
				3140	3170	E POM		
				3171	3180	E ENR		
				3171	3365	C DEPLOY		
				* * R E M A R K - SNFL 2-83				
				3161	3355	E OPCON		STANAVFORLANT
				3355	3365	E ENR	CONUS	
DDG	23	BYRD RE	N04690					
				3001	3064	E OPCON		COMIDEASTFOR
				3001	3075	C DEPLOY		
				* * R E M A R K - MEF 1-83				
				3065	3075	E ENR	CONUS	
				3076	3105	E LVUPK		
				3148	3157	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - UNITED EFFORT				
				3158	3168	E EXER	NORTH ATLANTIC	
				* * R E M A R K - OCEAN SAFARI 83				
				3180	3188	E EXER	NORTH ATLANTIC	
				* * R E M A R K - BALTOPS 83				
				3189	3198	E ENR	CONUS	
DDG	37	FARRAGUT	N52231					
				3001	3130	E OPCON		CINCUSNAVEUR
				3001	3140	C DEPLOY		
				* * R E M A R K - MED 1-83				

UNIT IDENTIFICATION				START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE ND.
				3131	3140	E ENR	CONUS	
				3141	3170	E LVUPK		
				3221	3238	E COMPTUEX		04-83
DDG	38	LUCE	N52232					
				3119	3131	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - SOLID SHIELD 83				
				3152	3168	E COMPTUEX		03-83
DDG	39	MCDONOUGH	N52233					
				3148	3157	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - UNITED EFFORT				
				3158	3168	E EXER	NORTH ATLANTIC	
				* * R E M A R K - OCEAN SAFARI 83				
				3180	3188	E EXER	NORTH ATLANTIC	
				* * R E M A R K - BALTOPS 83				
				3189	3198	E ENR	CONUS	
				3244	3263	E READEX		02-83
				3264	3293	E POM		
				3294	3303	E ENR	ROTA	
				3294	3365	C DEPLDY		
				* * R E M A R K - MED 1-84				
				3304	3365	E OPCON		CINCUSNAVEUR
DDG	40	COONTZ	N52234					
DDG	41	KING	N52235					
DDG	42	MAHAN	N52236					
				3031	3061	E POM		
				3062	3071	E ENR	ROTA	
				3062	3255	C DEPLDY		
				* * R E M A R K - IO 2-83				
				3071	3246	E OPCON		CINCPACFLT
				3246	3255	E ENR	CONUS	
				3256	3285	E LVUPK		
DDG	43	DAHLGREN	N52683					
				3001	3143	E OPCON		CINCPACFLT
				3001	3153	C DEPLDY		
				* * R E M A R K - IO 1-83				
				3144	3153	E ENR	CONUS	
				3154	3183	E LVUPK		
				3221	3238	E COMPTUEX		04-83
				3334	3349	E COMPTUEX		01-84
DDG	44	PRATT WV	N52684					
				3119	3131	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - SOLID SHIELD 83				
				3148	3157	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - UNITED EFFORT				
				3158	3168	E EXER	NORTH ATLANTIC	
				* * R E M A R K - OCEAN SAFARI 83				
				3180	3188	E EXER	NORTH ATLANTIC	
				* * R E M A R K - BALTOPS 83				
				3189	3198	E ENR	CONUS	
				3221	3239	E COMPTUEX		04-83
DDG	45	DEWEY	N52685					
				3107	3136	E POM		
				3137	3146	E ENR	ROTA	
				3137	3273	C DEPLOY		
				* * R E M A R K - MEF 3-83				
				3147	3163	E OPCON		COMIDEASTFOR

UNIT IDENTIFICATION				START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
				3264	3273	E ENR	CONUS	
				3274	3303	E LVUPK		
				3334	3349	E COMPTUEX		01-84
ODG	46	PREBLE	N52686					
				3148	3157	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - UNITED EFFORT				
				3158	3168	E EXER	NORTH ATLANTIC	
				* * R E M A R K - OCEAN SAFARI 83				
				3180	3188	E EXER	NORTH ATLANTIC	
				* * R E M A R K - BALTOPS 83				
				3189	3198	E ENR	CONUS	
OOG	993	KIDD	N21436					
				3069	3092	E READEX	CARIBBEAN SEA	01-83
				3093	3122	E POM		
				3123	3133	E ENR	ROTA	
				3123	3325	C DEPLOY		
				* * R E M A R K - MED 2-83				
				3133	3315	E OPCON		CINCUSNAVEUR
				3316	3325	E ENR	CONUS	
				3326	3355	E LVUPK		
DOG	995	SCOTT	N21438					
				3095	3112	E COMPTUEX		02-83
				3119	3131	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - SOLID SHIELD 83				
				3241	3270	E POM		
				3271	3281	E ENR	ROTA	
				3271	3365	C DEPLOY		
				* * R E M A R K - IO 1-84				
				3282	3365	E OPCON		CINCPACFLT
DD	944	MULLINNIX	N52203					
				3001	3130	E OPCON		CINCUSNAVEUR
				3001	3140	C DEPLOY		
				* * R E M A R K - MED 1-83				
				3131	3140	E ENR	CONUS	
				3141	3170	E LVUPK		
DD	963	SPRUANCE	N20574					
				3001	3030	E POM		
				3031	3040	E ENR	ROTA	
				3031	3254	C DEPLOY		
				* * R E M A R K - MEF 2-83				
				3041	3245	E OPCON		COMIDEASTFOR
				3246	3254	E ENR	CONUS	
				3255	3284	E LVUPK		
DD	968	RADFORD AW	N20588					
				3069	3092	E READEX	CARIBBEAN SEA	01-83
				3093	3122	E POM		
				3123	3133	E ENR	RDTA	
				3123	3325	C DEPLOY		
				* * R E M A R K - MED 2-83				
				3133	3315	E OPCON		CINCUSNAVEUR
				3316	3325	E ENR	CONUS	
				3326	3355	E LVUPK		
DD	969	PETERSON	N20589					
				3148	3157	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - UNITED EFFORT				
				3158	3168	E EXER	NORTH ATLANTIC	
				* * R E M A R K - OCEAN SAFARI 83				

UNIT IDENTIFICATION				START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
DD	970	CARON	N20590	3180	3188	E	EXER	NORTH ATLANTIC
				* * R E M A R K - BALTOPS 83				
				3189	3198	E	ENR	CONUS
				3095	3112	E	COMPTUEX	02-83
				3119	3131	E	EXER	ATLANTIC OCEAN
				* * R E M A R K - SOLIO SHIELD 83				
				3241	3270	E	POM	
				3271	3281	E	ENR	ROTA
				3271	3365	C	DEPLOY	
				* * R E M A R K - IO 1-84				
DD	974	COMTE DE GRASSE	N20600	3282	3365	E	OPCON	CINCPACFLT
				3001	3010	E	ENR	
				3001	3211	C	DEPLOY	
				* * R E M A R K - SNFL 1-83				
				3010	3201	E	OPCON	STANAVFORLANT
				3202	3211	E	ENR	CONUS
				3212	3242	E	LVUPK	
DD	977	BRISCOE	N20603	3334	3349	E	COMPTUEX	01-84
DD	978	STUMP	N20604	3001	3064	E	OPCON	COMIDEASTFOR
				3001	3075	C	DEPLOY	
				* * R E M A R K - MEF 1-83				
				3065	3075	E	ENR	CONUS
				3076	3105	E	LVUPK	
				3119	3131	E	EXER	ATLANTIC OCEAN
				* * R E M A R K - SOLIO SHIELD 83				
DD	979	CONOLLY	N20611	3152	3168	E	COMPTUEX	03-83
				3069	3092	E	READEX	CARIBBEAN SEA 01-83
				3093	3122	E	POM	
				3123	3133	E	ENR	ROTA
				3123	3325	C	DEPLOY	
				* * R E M A R K - MED 2-83				
				3133	3315	E	OPCON	CINCUSNAVEUR
				3316	3325	E	ENR	CONUS
				3326	3355	E	LVUPK	
DD	980	MOOSBRUGGER	N20612	3152	3168	E	COMPTUEX	03-83
				3221	3238	E	COMPTUEX	04-83
DD	981	HANCOCK J	N20613	3095	3112	E	COMPTUEX	02-83
DD	982	NICHOLSON	N20614	3221	3238	E	COMPTUEX	04-83
DD	983	RODGERS J	N20615	3152	3168	E	COMPTUEX	03-83
				3334	3349	E	COMPTUEX	01-84
DD	987	OBANNON	N20834	3148	3157	E	EXER	ATLANTIC OCEAN
				* * R E M A R K - UNITED EFFORT				
				3158	3168	E	EXER	NORTH ATLANTIC
				* * R E M A R K - OCEAN SAFARI 83				
				3180	3188	E	EXER	NORTH ATLANTIC
				* * R E M A R K - BALTOPS 83				

UNIT IDENTIFICATION				START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
				3189	3198	E ENR	CONUS	
DD	988	THORN	N20835					
				3221	3238	E COMPTUEX		04-83
				3334	3349	E COMPTUEX		01-84
DD	997	HAYLOR	N00000					
DD	989	OEYO	N20836					
				3095	3112	E COMPTUEX		02-83
				3119	3131	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - SOLID SHIELD 83				
				3166	3195	E POM		
				3196	3205	E ENR	ROTA	
				3196	3355	C OEPLOY		
				* * R E M A R K - MEF 4-83				
				3206	3345	E OPCON		COMIDEASTFOR
				3346	3355	E ENR	CONUS	
				3356	3365	E LVUPK		
FFG	4	TALBOT	N04695					
				3221	3238	E COMPTUEX		04-83
FFG	5	PAGE RL	N04698					
FFG	6	FURER JA	N04699					
				3095	3112	E COMPTUEX		02-83
				3148	3157	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - UNITED EFFORT				
				3158	3168	E EXER	NORTH ATLANTIC	
				* * R E M A R K - OCEAN SAFARI 83				
				3180	3188	E EXER	NORTH ATLANTIC	
				* * R E M A R K - BALTOPS 83				
				3189	3198	E ENR	CONUS	
FFG	7	PERRY OH	N21028					
				3001	3030	E POM		
				3031	3040	E ENR	ROTA	
				3031	3254	C OEPLOY		
				* * R E M A R K - MEF 2-83				
				3041	3245	E OPCON		COMIDEASTFOR
				3246	3254	E ENR	CONUS	
				3255	3284	E LVUPK		
FFG	8	MCINERNEY	N21032					
				3001	3130	E OPCON		CINCUSNAVEUR
				3001	3140	C DEPLOY		
				* * R E M A R K - MED 1-83				
				3131	3140	E ENR	CONUS	
				3141	3170	E LVUPK		
				3221	3238	E COMPTUEX		04-83
				3334	3349	E COMPTUEX		01-84
FFG	11	CLARK	N20964					
				3148	3157	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - UNITED EFFORT				
				3158	3168	E EXER	NORTH ATLANTIC	
				* * R E M A R K - OCEAN SAFARI 83				
				3180	3188	E EXER	NORTH ATLANTIC	
				* * R E M A R K - BALTOPS 83				
				3189	3198	E ENR	CONUS	
				3241	3270	E POM		
				3271	3281	E ENR	ROTA	
				3271	3365	C OEPLOY		
				* * R E M A R K - IO 1-84				

UNIT IDENTIFICATION			START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
			3282	3365	E OPCON		CINCPACFLT
FFG	13 MORISON SE	N20966					
			3152	3168	E COMPTUEX		03-83
			3244	3263	E READEX		02-83
			3264	3293	E POM		
			3294	3303	E ENR	ROTA	
			3294	3365	C DEPLOY		
			* * REMARK - MED 1-84				
			3304	3365	E OPCON		CINCUSNAVEUR
FFG	15 ESTOCIN	N20968					
			3095	3112	E COMPTUEX		02-83
			3152	3168	E COMPTUEX		03-83
			3221	3238	E COMPTUEX		04-83
			3334	3349	E COMPTUEX		01-84
FFG	16 SPRAGUE C	N20969					
			3001	3130	E OPCON		CINCUSNAVEUR
			3001	3140	C DEPLOY		
			* * REMARK - MED 1-83				
			3131	3140	E ENR	CONUS	
			3141	3170	E LVUPK		
			3221	3238	E COMPTUEX		04-83
			3334	3349	E COMPTUEX		01-84
FFG	20 ANTRIM	N20973					
			3095	3112	E COMPTUEX		02-83
			3244	3263	E READEX		02-83
			3264	3293	E POM		
			3294	3303	E ENR	ROTA	
			3294	3365	C DEPLOY		
			* * REMARK - MED 1-84				
			3304	3365	E OPCON		CINCUSNAVEUR
FFG	21 FLATLEY	N20974					
			3095	3112	E COMPTUEX		02-83
			3244	3263	E READEX		02-83
			3264	3293	E POM		
			3294	3303	E ENR	ROTA	
			3294	3365	C DEPLOY		
			* * REMARK - MED 1-84				
			3304	3365	E OPCON		CINCUSNAVEUR
FFG	22 FARIDN	N20975					
			3148	3157	E EXER	ATLANTIC OCEAN	
			* * REMARK - UNITED EFFORT				
			3158	3168	E EXER	NORTH ATLANTIC	
			* * REMARK - OCEAN SAFARI 83				
			3180	3188	E EXER	NORTH ATLANTIC	
			* * REMARK - BALTOPS 83				
			3189	3198	E ENR	CONUS	
FFG	24 WILLIAMS J	N20977					
			3152	3168	E COMPTUEX		03-83
			3244	3263	E READEX		02-83
			3264	3293	E POM		
			3294	3303	E ENR	ROTA	
			3294	3365	C DEPLOY		
			* * REMARK - MED 1-84				
			3304	3365	E OPCON		CINCUSNAVEUR
FFG	26 GALLERY	N20979					
			3095	3112	E COMPTUEX		02-83

UNIT IDENTIFICATION				START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
				3244	3263	E	READEX	02-83
				3264	3293	E	POM	
				3294	3303	E	ENR ROTA	
				3294	3365	C	DEPLOY	
				* * R E M A R K - MED 1-84				
				3304	3365	E	OPCON	CINCUSNAVEUR
FFG	28	BOONE	N21053					
FFG	29	GROVES SW	N21054	3221	3238	E	COMPTUEX	04-83
FFG	31	STARK	N21056	3334	3349	E	COMPTUEX	01-84
FFG	32	HALL JL	N21057					
				3334	3349	E	COMPTUEX	01-84
FFG	34	FITCH A	N21059					
FF	1038	MCCLOY	N54036					
				3119	3131	E	EXER ATLANTIC OCEAN	
				* * R E M A R K - SOLID SHIELD 83				
				3152	3168	E	COMPTUEX	03-83
				3244	3263	E	READEX	02-83
				3264	3293	E	POM	
				3294	3303	E	ENR ROTA	
				3294	3365	C	DEPLOY	
				* * R E M A R K - MED 1-84				
				3304	3365	E	OPCON	CINCUSNAVEUR
FF	1040	GARCIA	N54037					
				3095	3112	E	COMPTUEX	02-83
				3166	3195	E	POM	
				3196	3205	E	ENR ROTA	
				3196	3355	C	DEPLOY	
				* * R E M A R K - MED 4-83				
				3206	3345	E	OPCON	COMIDEASTFOR
				3346	3355	E	ENR CONUS	
				3356	3365	E	LVUPK	
FF	1043	MCDONNELL E	N54039					
				3001	3130	E	OPCON	CINCUSNAVEUR
				3001	3140	C	DEPLOY	
				* * R E M A R K - MED 1-83				
				3131	3140	E	ENR CONUS	
				3141	3170	E	LVUPK	
				3221	3238	E	COMPTUEX	04-83
				3334	3349	E	COMPTUEX	01-84
FF	1044	BRUMBY	N54040					
				3001	3143	E	OPCON	CINCPACFLT
				3001	3153	C	DEPLOY	
				* * R E M A R K - IO 1-83				
				3144	3153	E	ENR CONUS	
				3154	3183	E	LVUPK	
FF	1047	VOGE	N54042					
FF	1049	KOELSCH	N54044					
FF	1056	CONOLE	N54051					
				3001	3130	E	OPCON	CINCUSNAVEUR
				3001	3140	C	DEPLOY	
				* * R E M A R K - MED 1-83				
				3131	3140	E	ENR CONUS	
				3141	3170	E	LVUPK	
				3221	3238	E	COMPTUEX	04-83

UNIT IDENTIFICATION			START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
FF 1059	SIMS WS	N54054	3334	3349	E COMPTUEX		01-84
			3119	3131	E EXER	ATLANTIC OCEAN	
			* * R E M A R K - SOLID SHIELD 83				
			3152	3168	E COMPTUEX		03-83
			3221	3238	E COMPTUEX		04-83
			3244	3263	E READEX		02-83
			3264	3293	E PDM		
			3294	3303	E ENR	ROTA	
			3294	3365	C DEPLOY		
			* * R E M A R K - MED 1-84				
FF 1061	PATTERSON	N54056	3304	3365	E OPCON		CINCUSNAVEUR
			3152	3168	E COMPTUEX		03-83
			3334	3349	E COMPTUEX		01-84
FF 1068	VREELAND	N54063	3069	3092	E READEX	CARIBBEAN SEA	01-83
			3093	3122	E PDM		
			3123	3133	E ENR	ROTA	
			3123	3325	C DEPLOY		
			* * R E M A R K - MED 2-83				
			3133	3315	E OPCON		CINCUSNAVEUR
			3316	3325	E ENR	CONUS	
			3326	3355	E LVUPK		
FF 1072	BLAKELY	N54067	3095	3112	E COMPTUEX		02-83
			3119	3131	E EXER	ATLANTIC OCEAN	
			* * R E M A R K - SOLID SHIELD 83				
FF 1075	TRIPPE	N54070	3069	3092	E READEX	CARIBBEAN SEA	01-83
			3093	3122	E PDM		
			3123	3133	E ENR	ROTA	
			3123	3325	C DEPLOY		
			* * R E M A R K - MED 2-83				
			3133	3315	E OPCON		CINCUSNAVEUR
			3316	3325	E ENR	CONUS	
			3326	3355	E LVUPK		
FF 1078	HEWES J	N20049	3069	3092	E READEX	CARIBBEAN SEA	01-83
			3093	3122	E PDM		
			3123	3133	E ENR	ROTA	
			3123	3325	C DEPLOY		
			* * R E M A R K - MED 2-83				
			3133	3315	E OPCON		CINCUSNAVEUR
			3316	3325	E ENR	CONUS	
			3326	3355	E LVUPK		
FF 1079	BOWEN	N20050	3107	3136	E PDM		
			3137	3146	E ENR	ROTA	
			3137	3273	C DEPLOY		
			* * R E M A R K - MEF 3-83				
			3147	3163	E OPCON		COMIDEASTFOR
			3264	3273	E ENR	CONUS	
			3274	3303	E LVUPK		
FF 1080	PAUL	N20051	3334	3349	E COMPTUEX		01-84

UNIT IDENTIFICATION				START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
				3095	3112	E COMPTUEX		02-83
				3152	3168	E COMPTUEX		03-83
				3241	3270	E PCM		
				3271	3281	E ENR	ROTA	
				3271	3365	C DEPLOY		
				* * R E M A R K - IO 1-84				
				3282	3365	E OPCON		CINCPACFLT
FF	1081	AYLWIN	N20052					
				3119	3131	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - SOLID SHIELD 83				
				3152	3168	E COMPTUEX		03-83
				3244	3263	E READEX		02-83
				3264	3293	E POM		
				3294	3303	E ENR	ROTA	
				3294	3365	C DEPLOY		
				* * R E M A R K - MED 1-84				
				3304	3365	E OPCON		CINCUSNAVEUR
FF	1082	MONTGOMERY E	N20053					
FF	1084	MCCANDLESS	N20055					
FF	1085	BEARY DB	N20056					
				3031	3061	E POM		
				3062	3071	E ENR	ROTA	
				3062	3255	C DEPLOY		
				* * R E M A R K - IC 2-83				
				3071	3246	E OPCON		CINCPACFLT
				3246	3255	E ENR	CONUS	
				3256	3285	E LVUPK		
FF	1089	BROWN JL	N20067					
				3095	3112	E COMPTUEX		02-83
				3121	3151	E POM		
				3152	3344	E OPCON		COMSOLANT
				3152	3344	C DEPLOY		
				* * R E M A R K - UNITAS - WATC				
				3345	3365	E LVUPK		
FF	1090	AINSWORTH	N20068					
				3001	3130	E OPCON		CINCUSNAVEUR
				3001	3140	C DEPLOY		
				* * R E M A R K - MED 1-83				
				3131	3140	E ENR	CONUS	
				3141	3170	E LVUPK		
				3221	3238	E COMPTUEX		04-83
FF	1091	MILLER	N20069					
				3069	3092	E READEX	CARIBBEAN SEA	01-83
				3093	3122	E POM		
				3123	3133	E ENR	ROTA	
				3123	3325	C DEPLOY		
				* * R E M A R K - MED 2-83				
				3133	3315	E OPCON		CINCUSNAVEUR
				3316	3325	E ENR	CONUS	
				3326	3355	E LVUPK		
FF	1092	HART TC	N20070					
				3095	3112	E COMPTUEX		02-83
				3119	3131	E EXER	ATLANTIC OCEAN	
				* * R E M A R K - SOLID SHIELD 83				
				3121	3151	E POM		
				3152	3344	E OPCON		COMSOLANT

UNIT IDENTIFICATION			START	END	EMPLOYMENT	LOCATION	EMP UNIT/EXERCISE NO.
			3152	3344	C DEPLOY		
			* * R E M A R K - UNITAS - WATC				
			3345	3365	E LVUPK		
FF	1093	CAPODANNO	N20071				
			3001	3130	E OPCON		CINCUSNAVEUR
			3001	3140	C DEPLOY		
			* * R E M A R K - MED 1-83				
			3131	3140	E ENR	CONUS	
			3141	3170	E LVUPK		
FF	1094	PHARRIS	N20072				
			3031	3061	E POM		
			3062	3071	E ENR	ROTA	
			3062	3255	C DEPLOY		
			* * R E M A R K - IC 2-83				
			3071	3246	E OPCON		CINCPACFLT
			3246	3255	E ENR	CONUS	
			3256	3285	E LVUPK		
FF	1095	TRUETT	N20073				
			3119	3131	E EXER	ATLANTIC OCEAN	
			* * R E M A R K - SOLID SHIELD 83				
			3148	3157	E EXER	ATLANTIC OCEAN	
			* * R E M A R K - UNITED EFFORT				
			3158	3168	E EXER	NORTH ATLANTIC	
			* * R E M A R K - OCEAN SAFARI 83				
			3180	3188	E EXER	NORTH ATLANTIC	
			* * R E M A R K - BALTOPS 83				
			3189	3198	E ENR	CONUS	
FF	1096	VALDEZ	N20074				
			3069	3092	E READEX	CARIBBEAN SEA	01-83
			3093	3122	E POM		
			3123	3133	E ENR	ROTA	
			3123	3325	C DEPLOY		
			* * R E M A R K - MED 2-83				
			3133	3315	E OPCON		CINCUSNAVEUR
			3316	3325	E ENR	CONUS	
			3326	3355	E LVUPK		
FF	1097	MOINESTER	N20075				
			3069	3092	E READEX	CARIBBEAN SEA	01-83
			3093	3122	E POM		
			3123	3133	E ENR	ROTA	
			3123	3325	C DEPLOY		
			* * R E M A R K - MED 2-83				
			3133	3315	E OPCON		CINCUSNAVEUR
			3316	3325	E ENR	CONUS	
			3326	3355	E LVUPK		
FF	1098	GLOVER	N17700				
			3001	3130	E OPCON		CINCUSNAVEUR
			3001	3140	C DEPLOY		
			* * R E M A R K - MED 1-83				
			3131	3140	E ENR	CONUS	
			3141	3170	E LVUPK		
			3221	3238	E COMPTUEX		04-83
			3334	3349	E COMPTUEX		01-84

APPENDIX F

SAMPLE SOLVER OUTPUT REPORT

The Solver Output Report is a partial output report from the X System. The report lists all CPSKED row constraints with their associated ranges, penalties, and final solution values. The second part of the report lists the final solution by column, column cost, and column elements. Total solution time is printed at the bottom of the report.

EVENTLG SOLUTION OUTPUT

SYMBOL	CON	G-LOWER RNG	G-VAL	G-UPPER RNG	LOWER PEN	PENALTY	UPPER PEN
SHIP-SCHEDULE CONSTRAINTS FOLLOW:							
G	1	0.1000D+01	0.1000D+01	0.1000D+01	0.1000D+04	0.0	0.1000D+07
G	2	0.1000D+01	0.1000D+01	0.1000D+01	0.1000D+04	0.0	0.1000D+07
G	3	0.1000D+01	0.1000D+01	0.1000D+01	0.1278D+04	0.0	0.1000D+07
G	4	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	5	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	6	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	7	0.1000D+01	0.1000D+01	0.1000D+01	0.1183D+05	0.0	0.1000D+07
G	8	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	9	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	10	0.1000D+01	0.1000D+01	0.1000D+01	0.4191D+04	0.0	0.1000D+07
G	11	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	12	0.1000D+01	0.1000D+01	0.1000D+01	0.1448D+04	0.0	0.1000D+07
G	13	0.1000D+01	0.1000D+01	0.1000D+01	0.1367D+04	0.0	0.1000D+07
G	14	0.1000D+01	0.1000D+01	0.1000D+01	0.1031D+04	0.0	0.1000D+07
G	15	0.1000D+01	0.1000D+01	0.1000D+01	0.1482D+04	0.0	0.1000D+07
G	16	0.1000D+01	0.1000D+01	0.1000D+01	0.1117D+04	0.0	0.1000D+07
G	17	0.1000D+01	0.1000D+01	0.1000D+01	0.1187D+04	0.0	0.1000D+07
G	18	0.1000D+01	0.1000D+01	0.1000D+01	0.1000D+04	0.0	0.1000D+07
G	19	0.1000D+01	0.1000D+01	0.1000D+01	0.1007D+05	0.0	0.1000D+07
G	20	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	21	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	22	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	23	0.1000D+01	0.1000D+01	0.1000D+01	0.1407D+04	0.0	0.1000D+07
G	24	0.1000D+01	0.1000D+01	0.1000D+01	0.1004D+04	0.0	0.1000D+07
G	25	0.1000D+01	0.1000D+01	0.1000D+01	0.1281D+04	0.0	0.1000D+07
G	26	0.1000D+01	0.1000D+01	0.1000D+01	0.1344D+04	0.0	0.1000D+07
G	27	0.1000D+01	0.1000D+01	0.1000D+01	0.1456D+04	0.0	0.1000D+07
G	28	0.1000D+01	0.1000D+01	0.1000D+01	0.1595D+05	0.0	0.1000D+07
G	29	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	30	0.1000D+01	0.1000D+01	0.1000D+01	0.1072D+04	0.0	0.1000D+07
G	31	0.1000D+01	0.1000D+01	0.1000D+01	0.3351D+04	0.0	0.1000D+07
G	32	0.1000D+01	0.1000D+01	0.1000D+01	0.1391D+04	0.0	0.1000D+07
G	33	0.1000D+01	0.1000D+01	0.1000D+01	0.1497D+04	0.0	0.1000D+07
G	34	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	35	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	36	0.1000D+01	0.1000D+01	0.1000D+01	0.1298D+04	0.0	0.1000D+07
G	37	0.1000D+01	0.1000D+01	0.1000D+01	0.3759D+04	0.0	0.1000D+07
G	38	0.1000D+01	0.1000D+01	0.1000D+01	0.1114D+04	0.0	0.1000D+07
G	39	0.1000D+01	0.1000D+01	0.1000D+01	0.1171D+04	0.0	0.1000D+07
G	40	0.1000D+01	0.1000D+01	0.1000D+01	0.1322D+05	0.0	0.1000D+07
G	41	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.1000D+07
G	42	0.1000D+01	0.1000D+01	0.1000D+01	0.3374D+04	0.0	0.1000D+07
G	43	0.1000D+01	0.1000D+01	0.1000D+01	0.2171D+04	0.0	0.1000D+07
G	44	0.1000D+01	0.1000D+01	0.1000D+01	0.1323D+04	0.0	0.1000D+07

45	0.1000D+01	0.1000D+01	0.1000D+01	0.1522D+04	0.0	0.0	0.1000D+07
46	0.1000D+01	0.1000D+01	0.1000D+01	0.1411D+04	0.0	0.0	0.1000D+07
47	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.0	0.1000D+07
48	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.0	0.1000D+07
49	0.1000D+01	0.1000D+01	0.1000D+01	0.1371D+04	0.0	0.0	0.1000D+07
50	0.1000D+01	0.1000D+01	0.1000D+01	0.1249D+04	0.0	0.0	0.1000D+07
51	0.1000D+01	0.1000D+01	0.1000D+01	0.1387D+04	0.0	0.0	0.1000D+07
52	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.0	0.1000D+07
53	0.1000D+01	0.1000D+01	0.1000D+01	0.1112D+04	0.0	0.0	0.1000D+07
54	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.0	0.1000D+07
55	0.1000D+01	0.1000D+01	0.1000D+01	0.9597D+04	0.0	0.0	0.1000D+07
56	0.1000D+01	0.1000D+01	0.1000D+01	0.1218D+04	0.0	0.0	0.1000D+07
57	0.1000D+01	0.1000D+01	0.1000D+01	0.1278D+04	0.0	0.0	0.1000D+07
58	0.1000D+01	0.1000D+01	0.1000D+01	0.1195D+04	0.0	0.0	0.1000D+07
59	0.1000D+01	0.1000D+01	0.1000D+01	0.1305D+04	0.0	0.0	0.1000D+07
60	0.1000D+01	0.1000D+01	0.1000D+01	0.1204D+04	0.0	0.0	0.1000D+07
61	0.1000D+01	0.1000D+01	0.1000D+01	0.1027D+04	0.0	0.0	0.1000D+07
62	0.1000D+01	0.1000D+01	0.1000D+01	0.4367D+04	0.0	0.0	0.1000D+07
63	0.1000D+01	0.1000D+01	0.1000D+01	0.1148D+04	0.0	0.0	0.1000D+07
64	0.1000D+01	0.1000D+01	0.1000D+01	0.1000D+04	0.0	0.0	0.1000D+07
65	0.1000D+01	0.1000D+01	0.1000D+01	0.1103D+04	0.0	0.0	0.1000D+07
66	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.0	0.1000D+07
67	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.0	0.1000D+07
68	0.1000D+01	0.1000D+01	0.1000D+01	0.1133D+04	0.0	0.0	0.1000D+07
69	0.1000D+01	0.1000D+01	0.1000D+01	0.1109D+04	0.0	0.0	0.1000D+07
70	0.1000D+01	0.1000D+01	0.1000D+01	0.1147D+04	0.0	0.0	0.1000D+07
71	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.0	0.1000D+07
72	0.1000D+01	0.1000D+01	0.1000D+01	0.1439D+04	0.0	0.0	0.1000D+07
73	0.1000D+01	0.1000D+01	0.1000D+01	0.1439D+04	0.0	0.0	0.1000D+07
74	0.1000D+01	0.1000D+01	0.1000D+01	0.1316D+04	0.0	0.0	0.1000D+07
75	0.1000D+01	0.1000D+01	0.1000D+01	0.1439D+04	0.0	0.0	0.1000D+07
76	0.1000D+01	0.1000D+01	0.1000D+01	0.1448D+04	0.0	0.0	0.1000D+07
77	0.1000D+01	0.1000D+01	0.1000D+01	0.1106D+04	0.0	0.0	0.1000D+07
78	0.1000D+01	0.1000D+01	0.1000D+01	0.1056D+04	0.0	0.0	0.1000D+07
79	0.1000D+01	0.1000D+01	0.1000D+01	0.1009D+04	0.0	0.0	0.1000D+07
80	0.1000D+01	0.1000D+01	0.1000D+01	0.1070D+04	0.0	0.0	0.1000D+07
81	0.1000D+01	0.1000D+01	0.1000D+01	0.1006D+04	0.0	0.0	0.1000D+07
82	0.1000D+01	0.1000D+01	0.1000D+01	0.4414D+04	0.0	0.0	0.1000D+07
83	0.1000D+01	0.1000D+01	0.1000D+01	0.1452D+04	0.0	0.0	0.1000D+07
84	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.0	0.1000D+07
85	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.0	0.1000D+07
86	0.1000D+01	0.1000D+01	0.1000D+01	0.1046D+04	0.0	0.0	0.1000D+07
87	0.1000D+01	0.1000D+01	0.1000D+01	0.1040D+04	0.0	0.0	0.1000D+07
88	0.1000D+01	0.1000D+01	0.1000D+01	0.2500D+06	0.0	0.0	0.1000D+07
89	0.1000D+01	0.1000D+01	0.1000D+01	0.7199D+04	0.0	0.0	0.1000D+07
90	0.1000D+01	0.1000D+01	0.1000D+01	0.1195D+04	0.0	0.0	0.1000D+07
91	0.1000D+01	0.1000D+01	0.1000D+01	0.1808D+04	0.0	0.0	0.1000D+07
92	0.1000D+01	0.1000D+01	0.1000D+01	0.4208D+04	0.0	0.0	0.1000D+07
93	0.1000D+01	0.1000D+01	0.1000D+01	0.2597D+04	0.0	0.0	0.1000D+07
94	0.1000D+01	0.1000D+01	0.1000D+01				

95	0.10000D+01	0.10000D+01	0.10000D+01	0.20620D+04	0.0	0.10000D+07	0.10000D+07	
96	0.10000D+01	0.10000D+01	0.10000D+01	0.12110D+04	0.0	0.10000D+07	0.10000D+07	
97	0.10000D+01	0.10000D+01	0.10000D+01	0.14350D+04	0.0	0.10000D+07	0.10000D+07	
98	0.10000D+01	0.10000D+01	0.10000D+01	0.11960D+04	0.0	0.10000D+07	0.10000D+07	
99	0.10000D+01	0.10000D+01	0.10000D+01	0.10490D+04	0.0	0.10000D+07	0.10000D+07	
100	0.10000D+01	0.10000D+01	0.10000D+01	0.10000D+04	0.0	0.10000D+07	0.10000D+07	
101	0.10000D+01	0.10000D+01	0.10000D+01	0.21850D+05	0.0	0.10000D+07	0.10000D+07	
102	0.10000D+01	0.10000D+01	0.10000D+01	0.18560D+05	0.0	0.10000D+07	0.10000D+07	
103	0.10000D+01	0.10000D+01	0.10000D+01	0.25000D+06	0.0	0.10000D+07	0.10000D+07	
104	0.10000D+01	0.10000D+01	0.10000D+01	0.11710D+05	0.0	0.10000D+07	0.10000D+07	
105	0.10000D+01	0.10000D+01	0.10000D+01	0.14050D+05	0.0	0.10000D+07	0.10000D+07	
106	0.10000D+01	0.10000D+01	0.10000D+01	0.25000D+06	0.0	0.10000D+07	0.10000D+07	
107	0.10000D+01	0.10000D+01	0.10000D+01	0.17370D+05	0.0	0.10000D+07	0.10000D+07	
108	0.10000D+01	0.10000D+01	0.10000D+01	0.36690D+04	0.0	0.10000D+07	0.10000D+07	
109	0.10000D+01	0.10000D+01	0.10000D+01	0.73300D+04	0.0	0.10000D+07	0.10000D+07	
110	0.10000D+01	0.10000D+01	0.10000D+01	0.34390D+04	0.0	0.10000D+07	0.10000D+07	
111	0.10000D+01	0.10000D+01	0.10000D+01	0.25000D+06	0.0	0.10000D+07	0.10000D+07	
EVENT/SHIP-TYPE CONSTRAINTS FOLLOW:								
112	0.10000D+01	0.10000D+01	0.20000D+01	0.19320D+05	0.0	0.96610D+04		
113	0.20000D+01	0.20000D+01	0.30000D+01	0.19320D+05	0.0	0.96610D+04		
114	0.20000D+01	0.20000D+01	0.30000D+01	0.19320D+05	0.0	0.96610D+04		
115	0.10000D+01	0.10000D+01	0.20000D+01	0.19320D+05	0.0	0.96610D+04		
116	0.20000D+01	0.20000D+01	0.30000D+01	0.19320D+05	0.0	0.96610D+04		
117	0.50000D+01	0.50000D+01	0.70000D+01	0.19320D+05	0.0	0.96610D+04		
118	0.10000D+01	0.10000D+01	0.20000D+01	0.23100D+05	0.0	0.11550D+05		
119	0.10000D+01	0.10000D+01	0.20000D+01	0.23100D+05	0.0	0.11550D+05		
120	0.10000D+01	0.10000D+01	0.20000D+01	0.23100D+05	0.0	0.11550D+05		
121	0.10000D+01	0.10000D+01	0.20000D+01	0.23100D+05	0.0	0.11550D+05		
122	0.10000D+01	0.10000D+01	0.20000D+01	0.54760D+04	0.0	0.27380D+04		
123	0.10000D+01	0.10000D+01	0.20000D+01	0.54760D+04	0.0	0.27380D+04		
124	0.10000D+01	0.10000D+01	0.20000D+01	0.53820D+05	0.0	0.26910D+05		
125	0.10000D+01	0.10000D+01	0.20000D+01	0.44100D+05	0.0	0.22050D+05		
126	0.10000D+01	0.10000D+01	0.20000D+01	0.37250D+05	0.0	0.18620D+05		
127	0.10000D+01	0.10000D+01	0.20000D+01	0.37250D+05	0.0	0.18620D+05		
128	0.10000D+01	0.10000D+01	0.20000D+01	0.37250D+05	0.0	0.18620D+05		
129	0.10000D+01	0.20000D+01	0.20000D+01	0.37250D+05	0.0	0.18620D+05		
130	0.10000D+01	0.20000D+01	0.20000D+01	0.37250D+05	0.0	0.18620D+05		
131	0.10000D+01	0.10000D+01	0.20000D+01	0.50630D+05	0.0	0.25310D+05		
132	0.20000D+01	0.20000D+01	0.30000D+01	0.50630D+05	0.0	0.25310D+05		
133	0.20000D+01	0.20000D+01	0.30000D+01	0.50630D+05	0.0	0.25310D+05		
134	0.20000D+01	0.20000D+01	0.30000D+01	0.50630D+05	0.0	0.25310D+05		
135	0.30000D+01	0.30000D+01	0.50000D+01	0.50630D+05	0.0	0.25310D+05		
136	0.30000D+01	0.30000D+01	0.50000D+01	0.50630D+05	0.0	0.25310D+05		
137	C.20000D+01	0.30000D+01	0.30000D+01	0.28900D+03	0.0	0.14450D+03		
138	0.20000D+01	0.30000D+01	0.30000D+01	0.28900D+03	0.0	0.14450D+03		
139	C.20000D+01	0.30000D+01	0.30000D+01	0.28900D+03	0.0	0.14450D+03		
140	0.30000D+01	0.50000D+01	0.50000D+01	0.28900D+03	0.0	0.14450D+03		
141	C.30000D+01	0.50000D+01	0.50000D+01	0.18500D+05	0.0	0.92480D+04		
142	C.10000D+01	0.10000D+01	0.20000D+01	0.18500D+05	0.0	0.92480D+04		
143	C.10000D+01	0.10000D+01	0.20000D+01	0.18500D+05	0.0	0.92480D+04		
144	0.10000D+01	0.20000D+01	0.20000D+01	0.14400D+03	0.0	0.72000D+02		

G	145	0.2000D+01	0.3000D+01	0.3000D+01	0.1440D+03	0.0	0.7200D+02
G	146	0.2000D+01	0.3000D+01	0.3000D+01	0.1440D+03	0.0	0.7200D+02
G	147	0.2000D+01	0.3000D+01	0.3000D+01	0.1440D+03	0.0	0.7200D+02
G	148	0.2000D+01	0.3000D+01	0.3000D+01	0.1440D+03	0.0	0.7200D+02
G	149	0.2000D+01	0.3000D+01	0.3000D+01	0.1440D+03	0.0	0.7200D+02
G	150	0.1000D+01	0.1000D+01	0.2000D+01	0.3764D+05	0.0	0.1882D+05
G	151	0.1000D+01	0.1000D+01	0.2000D+01	0.1296D+04	0.0	0.6480D+03
G	152	0.2000D+01	0.3000D+01	0.3000D+01	0.1296D+04	0.0	0.6480D+03
G	153	0.1000D+01	0.2000D+01	0.2000D+01	0.1296D+04	0.0	0.6480D+03
G	154	0.2000D+01	0.3000D+01	0.3000D+01	0.1296D+04	0.0	0.6480D+03
G	155	0.2000D+01	0.3000D+01	0.3000D+01	0.1296D+04	0.0	0.6480D+03
G	156	0.2000D+01	0.3000D+01	0.3000D+01	0.2560D+03	0.0	0.1280D+03
G	157	0.2000D+01	0.3000D+01	0.3000D+01	0.2560D+03	0.0	0.1280D+03
G	158	0.2000D+01	0.3000D+01	0.3000D+01	0.2560D+03	0.0	0.1280D+03
G	159	0.3000D+01	0.3000D+01	0.5000D+01	0.2560D+03	0.0	0.1280D+03
G	160	0.3000D+01	0.5000D+01	0.5000D+01	0.2560D+03	0.0	0.1280D+03
G	161	0.1000D+01	0.1000D+01	0.2000D+01	0.3686D+05	0.0	0.1843D+05
G	162	0.1000D+01	0.1000D+01	0.2000D+01	0.3686D+05	0.0	0.1843D+05
G	163	0.1000D+01	0.1000D+01	0.2000D+01	0.3686D+05	0.0	0.1843D+05
G	164	0.1000D+01	0.1000D+01	0.2000D+01	0.2528D+05	0.0	0.1264D+05
G	165	0.1000D+01	0.1000D+01	0.2000D+01	0.2528D+05	0.0	0.1264D+05
G	166	0.2000D+01	0.3000D+01	0.3000D+01	0.2890D+03	0.0	0.1445D+03
G	167	0.2000D+01	0.3000D+01	0.3000D+01	0.2890D+03	0.0	0.1445D+03
G	168	0.2000D+01	0.3000D+01	0.3000D+01	0.2890D+03	0.0	0.1445D+03
G	169	0.3000D+01	0.5000D+01	0.5000D+01	0.2890D+03	0.0	0.1445D+03
G	170	0.3000D+01	0.5000D+01	0.5000D+01	0.2890D+03	0.0	0.1445D+03
G	171	0.1000D+01	0.1000D+01	0.2000D+01	0.8836D+04	0.0	0.4418D+04
G	172	0.1000D+01	0.2000D+01	0.2000D+01	0.8836D+04	0.0	0.4418D+04
G	173	0.1000D+01	0.2000D+01	0.2000D+01	0.8836D+04	0.0	0.4418D+04
G	174	0.1000D+01	0.1000D+01	0.2000D+01	0.8100D+04	0.0	0.4050D+04
G	175	0.2000D+01	0.3000D+01	0.3000D+01	0.8100D+04	0.0	0.4050D+04
G	176	0.2000D+01	0.2000D+01	0.3000D+01	0.8100D+04	0.0	0.4050D+04
G	177	0.2000D+01	0.2000D+01	0.3000D+01	0.8100D+04	0.0	0.4050D+04
G	178	0.3000D+01	0.3000D+01	0.5000D+01	0.8100D+04	0.0	0.4050D+04
G	179	0.3000D+01	0.3000D+01	0.5000D+01	0.8100D+04	0.0	0.4050D+04
G	180	0.2000D+01	0.3000D+01	0.3000D+01	0.2250D+03	0.0	0.1125D+03
G	181	0.2000D+01	0.3000D+01	0.3000D+01	0.2250D+03	0.0	0.1125D+03
G	182	0.2000D+01	0.3000D+01	0.3000D+01	0.2250D+03	0.0	0.1125D+03
G	183	0.3000D+01	0.5000D+01	0.5000D+01	0.2250D+03	0.0	0.1125D+03
G	184	0.3000D+01	0.5000D+01	0.5000D+01	0.2250D+03	0.0	0.1125D+03
WEAPON SYSTEM CAPABILITY CONSTRAINTS FOLLOW:							
G	185	0.2000D+01	0.1000D+01	0.7000D+01	0.1000D+04	0.1000D+04	0.1000D+02
G	186	0.4000D+01	0.5000D+01	0.9000D+01	0.1000D+04	0.0	0.1000D+02
G	187	0.3000D+01	0.2000D+01	0.8000D+01	0.1000D+04	0.1000D+04	0.1000D+02
G	188	0.4000D+01	0.3000D+01	0.9000D+01	0.1000D+04	0.1000D+04	0.1000D+02
G	189	0.3000D+01	0.5000D+01	0.8000D+01	0.1000D+04	0.0	0.1000D+02
G	190	0.3000D+01	0.9000D+01	0.8000D+01	0.1000D+04	0.1000D+02	0.1000D+02
G	191	0.4000D+01	0.1000D+02	0.9000D+01	0.1000D+04	0.1000D+02	0.1000D+02
G	192	0.1000D+01	0.2000D+01	0.6000D+01	0.1000D+04	0.0	0.1000D+02
G	193	0.2000D+01	0.0	0.7000D+01	0.1000D+04	0.2000D+04	0.1000D+02
G	194	0.2000D+01	0.2000D+01	0.7000D+01	0.1000D+04	0.0	0.1000D+02
G	195	0.2000D+01	0.1000D+01	0.7000D+01	0.1000D+04	0.1000D+04	0.1000D+02

196	0.2000D+01	0.1000D+01	0.7000D+01	0.1000D+04	0.1000D+04	0.0	0.1000D+02
197	0.1000D+01	0.1000D+01	0.6000D+01	0.1000D+04	0.0	0.0	0.1000D+02
198	0.1000D+01	0.1000D+01	0.6000D+01	0.1000D+04	0.0	0.0	0.1000D+02
199	0.1000D+01	0.1000D+01	0.6000D+01	0.1000D+04	0.0	0.0	0.1000D+02
200	0.1000D+01	0.2000D+01	0.6000D+01	0.1000D+04	0.0	0.0	0.1000D+02
201	0.1000D+01	0.1000D+01	0.6000D+01	0.1000D+04	0.0	0.0	0.1000D+02
202	0.2000D+01	0.2000D+01	0.7000D+01	0.1000D+04	0.0	0.0	0.1000D+02
203	0.2000D+01	0.2000D+01	0.7000D+01	0.1000D+04	0.0	0.0	0.1000D+02
204	0.2000D+01	0.2000D+01	0.7000D+01	0.1000D+04	0.0	0.0	0.1000D+02
205	0.2000D+01	0.3000D+01	0.7000D+01	0.1000D+04	0.0	0.0	0.1000D+02
206	0.2000D+01	0.1000D+01	0.7000D+01	0.1000D+04	0.1000D+04	0.0	0.1000D+02
207	0.4000D+01	0.3000D+01	0.9000D+01	0.1000D+04	0.1000D+04	0.0	0.1000D+02
208	0.3000D+01	0.2000D+01	0.8000D+01	0.1000D+04	0.1000D+04	0.0	0.1000D+02
209	0.4000D+01	0.5000D+01	0.9000D+01	0.1000D+04	0.0	0.0	0.1000D+02
210	0.3000D+01	0.8000D+01	0.8000D+01	0.1000D+04	0.2000D+02	0.0	0.1000D+02
211	0.3000D+01	0.1000D+02	0.8000D+01	0.1000D+04	0.3000D+02	0.0	0.1000D+02
212	0.4000D+01	0.1200D+02	0.9000D+01	0.1000D+04	0.0	0.0	0.1000D+02
213	0.1000D+01	0.1000D+01	0.6000D+01	0.1000D+04	0.0	0.0	0.1000D+02
214	0.1000D+01	0.1000D+01	0.6000D+01	0.1000D+04	0.0	0.0	0.1000D+02
215	0.1000D+01	0.1000D+01	0.6000D+01	0.1000D+04	0.0	0.0	0.1000D+02
216	0.1000D+01	0.2000D+01	0.6000D+01	0.1000D+04	0.0	0.0	0.1000D+02
217	0.1000D+01	0.1000D+01	0.6000D+01	0.1000D+04	0.0	0.0	0.1000D+02
218	0.2000D+01	0.2000D+01	0.7000D+01	0.1000D+04	0.0	0.0	0.1000D+02
219	0.2000D+01	0.3000D+01	0.7000D+01	0.1000D+04	0.0	0.0	0.1000D+02
220	0.2000D+01	0.2000D+01	0.7000D+01	0.1000D+04	0.0	0.0	0.1000D+02
221	0.2000D+01	0.4000D+01	0.7000D+01	0.1000D+04	0.0	0.0	0.1000D+02
222	0.4000D+01	0.6000D+01	0.9000D+01	0.1000D+04	0.0	0.0	0.1000D+02
223	0.3000D+01	0.3000D+01	0.8000D+01	0.1000D+04	0.0	0.0	0.1000D+02
224	0.4000D+01	0.4000D+01	0.9000D+01	0.1000D+04	0.0	0.0	0.1000D+02
225	0.3000D+01	0.3000D+01	0.8000D+01	0.1000D+04	0.0	0.0	0.1000D+02
226	0.3000D+01	0.9000D+01	0.8000D+01	0.1000D+04	0.1000D+02	0.0	0.1000D+02
227	0.4000D+01	0.8000D+01	0.9000D+01	0.1000D+04	0.0	0.0	0.1000D+02
228							

OBJECTIVE VALUE = 0.4467D+04

SHIP-SCHEDULE PENALTIES = 0.0

EVENT/SHIP-TYPE PENALTIES = 0.0

WEAPON	SYSTEM CAPABILITIES	PENALTIES = 0.9080D+04	
1	0.0	1	
2	0.0	2	
4	203.70	3	144
5	17559.27	4	174
6	30109.61	5	118
7	34914.19	6	112 151
9	156.21	7	144
10	27344.39	8	131
11	51027.10	9	127
25	61.30	10	137 145 156 166 171 217 219
110	1059.45	11	119 166 180 192 194
154	2019.28	12	137 175 222 224 225 228
203	1558.35	13	132 206 208 209 212
299	31.26	14	
313	173.28	15	137 145 180
426	7575.79	16	152 175 222 224 225 228
457	63.49	17	156 180
465	0.0	18	
467	14987.88	19	132 207 208 209 211 212
563	18933.37	20	128 202 203 205
564	2953.18	21	113 186 187 188 190 191
566	1315.47	22	113 166 186 187 188 190 191
647	2718.37	23	156 175 222 224 225 227 228
656	3.60	24	
774	184.20	25	157
796	6338.39	26	133 207 212
1035	10214.58	27	138 161
1164	985.11	28	
1165	154.41	29	114 186 191
1169	72.01	30	
1173	778.19	31	129 181 202
1571	3051.61	32	157 176 223 228
1586	20178.20	33	138 146 150
1834	184.22	34	122 152
1846	3766.28	35	114 167 185 188 191
1909	136.22	36	146 157
2179	2974.21	37	153 176 222 225 228
2211	114.12	38	
2215	171.05	39	
2233	1262.79	40	129 201 203
2336	4236.99	41	120 167 181 192 194
2499	71.20	42	145 152 167
2674	2731.97	43	142 181 213
2905	116.00	44	153
2943	4883.94	45	133 207 209 211 212
3188	3770.71	46	138 146 172 218 219 221
3332	498.73	47	115 191
3333	31054.19	48	124 199 200
3337	3021.48	49	134 209 210 211 212
3553	82.41	50	154
3598	5519.54	51	139 147 172 219 220 221

3734	30024.99	52	126					
3738	57.50	53	182					
3741	1436.96	54	123	147	158	197	198	
3748	3920.61	55	134	209	210	211	212	
4017	66.84	56	158	168				
4035	28.00	57						
4079	97.47	58	139	168				
4189	60.48	59	158	182				
4304	105.49	60	154					
4362	62.04	61	168	182				
4367	26.95	62						
4396	13732.32	63	139	147	164	215	216	
4600	77.09	64	169					
4603	0.0	65						
4693	123.85	66	140	155				
4907	25491.19	67	125	200				
4910	8.70	68	116	169	183	186	190	
5177	242.22	69	155	173	218	221		
5473	160.68	70	159	179	223	227		
5603	24.43	71	140	159	169	183		
5778	3.82	72	116	169	183	186	190	
5878	241.75	73	140	179	223	227		
6119	216.97	74	140	178	223	227		
6426	111.73	75	155					
6694	222.90	76	159	178	223	227		
6806	825.59	77	140	178	223	227		
6954	47.38	78	169					
6958	20.14	79	183					
6959	0.0	80						
6961	29.01	81	183					
6962	6.23	82						
7132	72.88	83	148	160	177	226	227	228
7249	5683.50	84	141	165	216			
7375	16.76	85	117	170	184	189	190	191
7377	74.05	86	121	195	196			
7380	46.09	87						
7382	39.56	88						
7386	56.51	89	117	170	184	189	190	191
7521	722.53	90	149	160	170	177	226	227 228
7634	60.48	91	160	184				
7646	1506.87	92	135	210	211	212		
7924	53.81	93	141	148				
7931	3335.04	94	136	210	211	212		
8184	277.25	95	135	210	211	212		
8493	2764.55	96	143	184	214			
8681	3159.01	97	141	160	173	220	221	
8916	2549.95	98	149	160	179	226	227	228
9013	48.84	99						
9015	0.0	100						
9017	1531.31	101	130	204	205			
9233	4154.07	102	141	163				
9377	135.15	103	117	170	189	190	191	
9381	2045.05	104	136	210	211	212		
9674	4680.98	105	141	149	162			
9915	1790.74	106	117	189	190	191		
9917	6565.31	107	130	204	205			
10148	19.66	108	148	154				
10173	3555.12	109	136	210	211	212		
10452	2552.99	110	135	210	211	212		
10722	405.18	111	117	170	184	189	190	191

SOLUTION TIME= 82.36

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